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Radiology

Knee Cysts and Pseudocysts: An Illustrated Review of the Different MRI Aspects

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Abstract	**Review Article**

The discovery of an intra- or periarticular cystic image is a frequent occurrence when performing MRI of the knee. Although the majority of these lesions are benign, cystic lesions can sometimes lead to misdiagnosis. It is important for the radiologist to be familiar with these entities, their specific anatomical locations and potential pitfalls, to avoid misdiagnosis and inappropriate interventions. MRI is the modality of choice for localizing and characterizing cystic lesions around the knee. The purpose of this work is to present an illustrated review of cystic and pseudocystic lesions of the knee and their characteristics on MRI.
Keywords: Cyst, synovial cyst, mucoid cyst, bursae, pseudo-cyst, knee, Magnetic Resonance Imaging.

INTRODUCTION

The discovery of an intra- or periarticular cystic image is a common occurrence during MRI of the knee.These cystic lesions can correspond either to bursitis developed in very numerous sliding bursae near the knee, or to mucoid cysts neo-formed in intra- or periarticular connective tissue (Beall *et al.,* 2005; Marra *et al.,* 2008; McCarthy et McNally, 2004; Ward *et al.,* 2001). Diagnosis of these cysts is essentially based on the topography of the cyst and analysis of its relationship to neighbouring anatomical structures, such as a tendon, ligament, meniscus or bone surface, in one of the four sectors of the knee: anterior, posterior, lateral and medial. MRI is the modality of choice for localizing and characterizing cystic lesions around the knee (Tavernier et Dejour, 2001). The purpose of this work is to provide a didactic approach to understanding the different pathologies responsible for cysts around the knee, and to identify the specific signs on MRI, thus facilitating etiological orientation. To facilitate classification, cystic lesions were subdivided as follows: synovial cysts, mucoid cysts (intra- articular and para- articular), bursitis and pseudo-cystic lesions around the knee, and then a division according to compartments was proposed.

A- Etiologies:
1-Synovial Cysts

Synovial cysts are lesions of articular origin, corresponding to a herniation of the synovial membrane through the joint capsule, reflecting joint hyperpressure or abnormal distension of the bursae communicating with the adjacent joint. They contain synovial fluid and their walls are lined with synoviocytes (Tavernier et Dejour, 2001).

1.1- Popliteal Cyst:

First described in 1877 by Baker (Østergaard *et al.,* 1995), popliteal cyst is the most common cystic lesion of the knee. It corresponds to liquid distension of the bursa common to the tendons of the semimembranosus and medial gastrocnemius (Beaman et Peterson, 2007). It is most often secondary to benign pathology (degenerative, traumatic, systemic inflammatory). It is rarely idiopathic. On MRI, the cyst is well limited, hyposignal T1 and hypersignal T2. Injection of gadolinium may enhance the cyst wall. The diagnosis of certainty is then based on the demonstration of a liquid extension between the tendons of the medial head of the gastrocnemius muscle and the semimembranosus muscle (Figure 1) (Marra *et al.,* 2008; Murphey *et al.,* 1993)
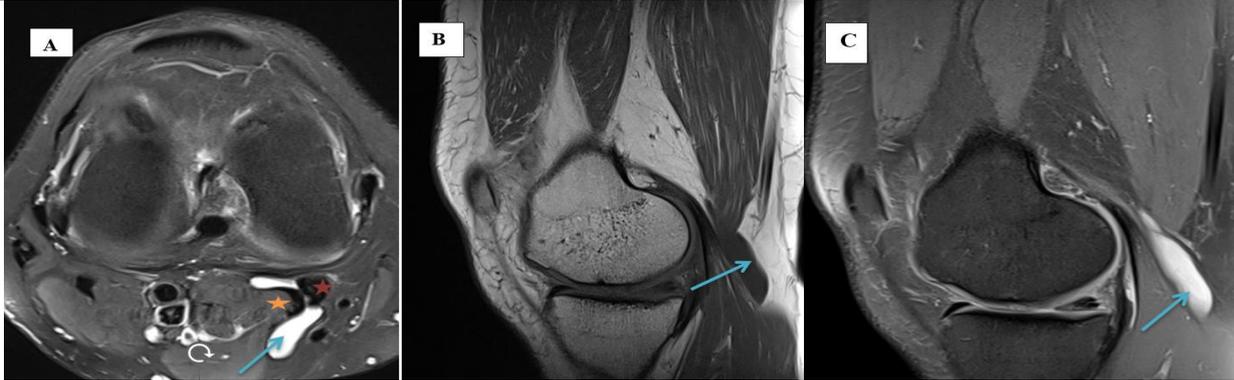
Figure 1: MRI of the knee, in axial DP (A), sagittal DP (B) and T1 (C) sections, showing a fluid collection between the tendons of the medial head of the gastrocnemius muscle (★)and the semimembranosus muscle (★) in T1 hyposignal, T2 hyper signal in relation to a simple Baker cyst.

1.2- Proximal Tibiofibular Joint Cysts

In 10% of adults, the proximal tibiofibular joint communicates with the knee joint. The probable pathogenesis of proximal tibiofibular joint lesions is an increase in pressure in the knee joint, leading to effusion of the tibiofibular joint capsule, with consequent herniation to form the synovial cyst They are therefore more common in patients with osteoarthritis of the knee. Synovial cysts in this location are rare, with a reported prevalence of between 0.09% and 0.76% (Jerome et McKendry, 2000). Synovial cysts in the proximal tibiofibular joint are easily recognized on MRI, appearing as a homogeneous, fusiform fluid lesion communicating with the proximal tibiofibular joint through a fistulous path (Figure 2). Rarely, large cysts may cause erosion of adjacent bone. The differential diagnosis includes tumours such as schwannoma or neurofibroma of the common peroneal nerve, synovial sarcoma and juxta-articular mixoma. Cruciate ligament cysts may also pose a differential diagnosis problem, with villonodular synovitis evoked by hemosiderin deposits on gradient echo sequences, or more rarely with hemangioma or even synovialosarcoma (Pialat *et al.,* 2002).

Figure 2: MRI of the knee, in coronal (A), axial (B) and sagittal (C) DP sections, showing cystic formation of the tibio-peroneal joint (arrow)

2- Mucoid Cysts

Mucoid cysts represent a more polymorphous etiology. Their wall is usually fibro-conjunctive in nature, and their etiopathogenesis remains controversial. The most widely accepted hypothesis in the literature suggests that they originate from a leak of articular synovial fluid around which a fibroconjunctive tissue devoid of synovial lining is organized (Burk *et al.,* 1988). These mucoid cysts may be located intra-articularly or para-articularly.

2-1-Intra-articular Mucoid Cysts

Mucoid cysts may develop intra-articularly in Hoffa's infrapatellar fat or in the proximity of the cruciate ligaments.

2.1.1-Meniscal Cysts:

Meniscal cysts are linked to the existence of a horizontal or complex fissure in a meniscus into which joint fluid insinuates and collects. When the fissure is incomplete, the cyst is located within the meniscus (Figure 3) and is often small (Bergin *et al.,* 2004; Murphey *et al.,* 1993, Perdikakis et Skiadas, 2013; Shikhare *et al.,* 2018; Tyson *et al.,* 1995).
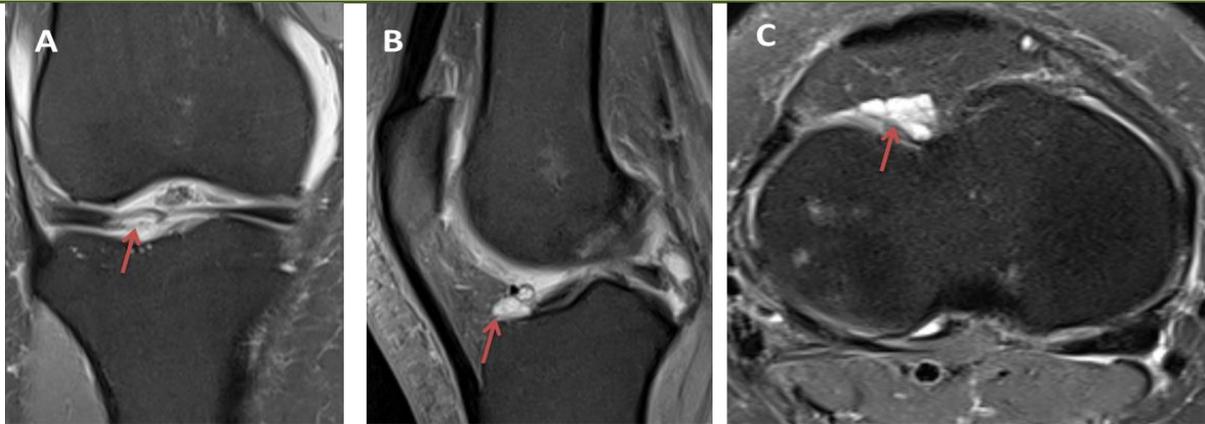
Figure 3: MRI of the knee, DP sequence, in coronal (A), sagittal (B) and axial (C) sections, showing a mucoid cyst on the anterior horn of the lateral meniscus

When the fissure reaches the capsular margin of the meniscus, the cyst is located para-meniscally (Figure 4) and may extend either vertically or horizontally, while remaining in contact with the meniscus. (Bergin *et al.,* 2004; Perdikakis et Skiadas, 2013).
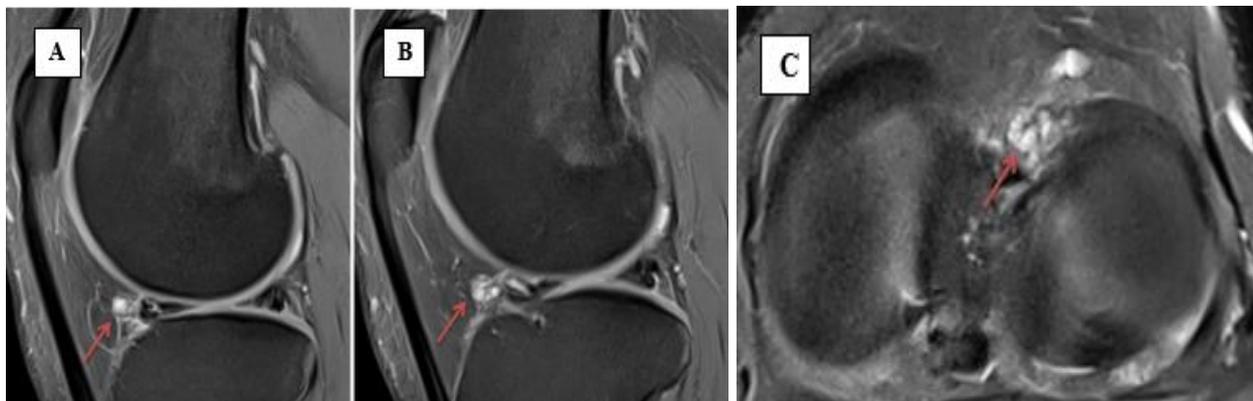
Figure 5: MRI of the knee in sagittal (A and B) and axial C) and DP sequences, showing a para-meniscal mucoid cyst opposite the anterior horn of the lateral meniscus, the site of a complex fissure

The cyst may extend posteriorly and should not be confused with a popliteal cyst. When the extension is forward, between the deep and superficial bundles of the medial collateral ligament, it should not be confused with bursitis of the medial collateral ligament. Damage to the lateral meniscus more often involves the middle and anterior segments of the meniscus. Often less voluminous than medial meniscus cysts, they extend vertically without perforating the capsule. MRI is the reference diagnostic test, more sensitive than clinical examination and arthroscanner. It shows the cyst and its extent, and provides a precise description of the underlying meniscus lesion (Bergin *et al.,* 2004).

2.1. 2- Mucoid cysts of the cruciate ligaments:
The frequency of these cysts is estimated at 1%. They most frequently involve the anterior cruciate ligament (ACL). ACL cysts are spindle-shaped, oriented along the long axis of the ligament, with a liquid signal and sometimes multiloculated cystic expansion. When the cyst is purely intraligamentary (Figure 6), the ligament appears enlarged and fan-shaped (Janzen *et al.,* 1994). Posterior cruciate ligament cysts develop in contact with the posterior surface of the ligament and most often present as multiloculated cystic lesions (Figure 7) (Krudwig *et al.,* 2004).

MRI is the gold standard for diagnosis. The ligament appears hypertrophied and signal-enhanced on T1- and T2-weighted sequences, giving it an appearance similar to that of a ligament rupture. The clinical context and the visualization of dissociated but continuous ligament fibers within the hypersignal on T2-weighted sequences remove any doubt. Its relationship with the popliteal vessels needs to be investigated.
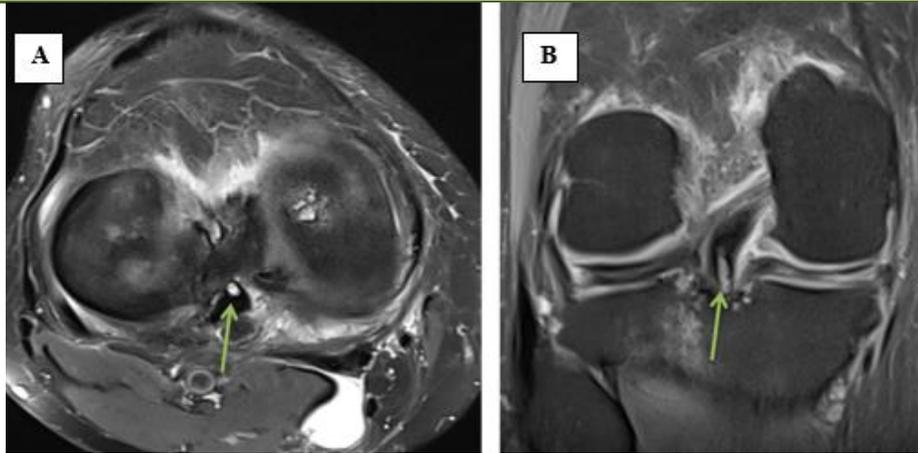
Figure 6: DP MRI of the knee in axial and coronal sections showing an intra-ligament cystic formation in hyposignal T1 hypersignal T2 visible at PCL level in connection with a mucoid cyst
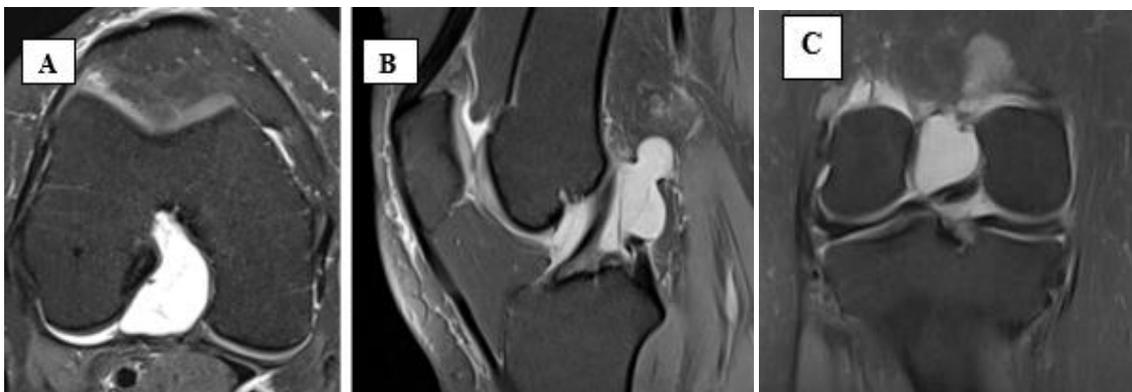

Figure 7: MRI of the knee in axial(A), sagittal(B) and coronal (C)sections showing cystic formation of the inter-condylar notch surrounding the cruciate ligaments, related to a mucoid cyst of the inter-condylar notch

2.1. 3- Hoffa's mucoid fat cysts

The Hoffa fat pack may be the site of cystic formations of variable size and location (Wu & Hochman, 2009). MRI is a powerful diagnostic tool, identifying a liquid-signal lesion most often located anterior to the anterior horn of the lateral meniscus (Figure 8). The absence of meniscal fissure distinguishes it from anterior meniscal cysts (Samim *et al.,* 2014 ; Wu & Hochman, 2009). Hoffa's mucoid fat cyst must also be differentiated from deep infrapatellar bursitis and Hoffa's posteroinferior recess, present in 15-45% of the population. The later presents as a fluid image located in front of the anterior horn of the meniscus, connected to the joint space by a pertus and identical in signal to the joint fluid (Beaman & Peterson, 2007; Bergin *et al.,* 2004; Ilahi *et al.,* 2003).

Figure 8: MRI of the knee, in DP sagittal (A), T1 sagittal (B) and DP axial (C) sections showing Hoffa's fat cystic formation in DP hypersignal T1 hyposignal

2.2-Para-articular mucoid cysts:

These can be found anywhere near of joints: in the bone, in juxta-articular cellulo-fatty tissue, in muscles or sub-periosteally.

2.2.1-Intraosseous cysts

The knee is a frequent site for intraosseous mucoid cysts. They may be subchondral, but also in bony structures not covered by cartilage, such as in the central part of the tibia or on the posterior side of the inferior femoral metaphysis. MRI shows a cystic lesion without perilesional edema (Figure 9) ; (Bergin *et al.,* 2004 ; Liu *et al.,* 2007 ; Yoon *et al.,* 2014)
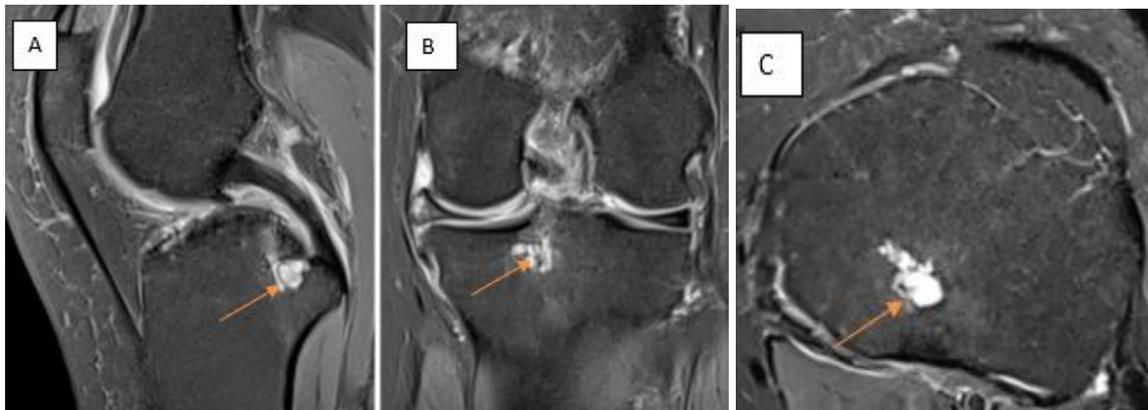

Figure 9: MRI of the knee in DP axial (A), sagittal (B), coronal (C) and T1 sagittal (D) sequences showing multiple subchondral intraosseous cystic formations juxtaposed at the tibial level, in T1 hyposignal and T2 hypersignal and DP in relation to mucoid cysts

2.2.2-Insertional mucoid cysts :

Insertional cysts are most likely the result of bone resorption due to chronic stress at the insertion of cruciate ligaments and, possibly, menisco-tibial attachments. These stresses may also lead to focal necrosis of the bone, resulting in cyst formation. These lesions have been reported in 1% of patients undergoing MRI of the knee. On MRI, they appear as well-defined, homogeneous, fluid-filled lesions, usually with a hypointense wall due to dense fibrous tissue (Figure 10). Areas of edema of the adjacent bone marrow may be associated. Insertional cysts may be multiple. (Bancroft *et al.,* 2004).

Figure 10: MRI of the knee in 3 planes (A: sagittal, B: coronal, C: axial) showing a subchondral intraosseous cystic formation opposite the tibial insertion of the posterior cruciate ligament

2.2.3-The adventitial arterial cyst

The mucoid collection is located in the adventitia. It is responsible for more or less severe stenosis of the arterial lumen. This is a rare pathology to be considered in young patients with no vascular risk factors and intermittent claudication. They differentiate the lesion from an arterial aneurysm. MRI is more effective in visualizing the adventitial cyst and differentiating it from a popliteal cyst or a mucoid cyst of the posterior cruciate ligament (Figure 11). Communication between the cyst and the joint is rarely demonstrated on imaging. (Beaman et Peterson, 2007 ; Perdikakis et Skiadas, 2013)

Figure 11: Adventitial cyst of the popliteal artery. Axial T2 Fat Sat MRI sequence. Cystic image (arrow) developed in the wall of the popliteal artery (arrowhead), which is stenotic

d-The intraneural cyst

Nerve sheaths may be the site of a mucoid cyst. Involvement of the common fibular nerve is the most common. Communication with the tibiofibular joint is not always evident. The cyst may cause nerve compression, leading to pain and sensory-motor deficit. Distinguishing a cyst from a proximal tibiofibular cyst is sometimes difficult, especially as the latter may compress the common fibular nerve, causing identical symptoms. Post-operative MRI can help determine the precise extent of the lesion and its anatomical relationship with adjacent structures (Beaman et Peterson, 2007; Ilahi *et al.,* 2003).

e-Other localizations

Mucoid cysts of the soft tissues are frequently encountered and may be of variable location. Intramuscular cysts are rarely symptomatic. When their contents are thick, they may be difficult to detect on T1-weighted sequences due to a signal identical to the adjacent muscle (figure.13). Intravenous injection of contrast medium helps to identify them and rule out a tumour with a cystic component (Marra *et al.,* 2008 ; Shikhare *et al.,* 2018).
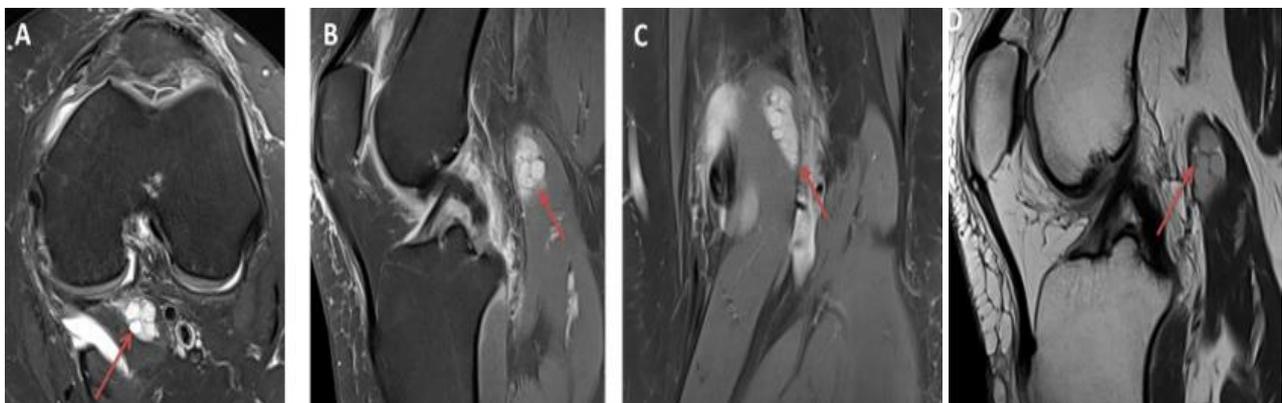
Figure 12: MRI of the knee in axial DP (A), sagittal (B), coronal (C) and sagittal T2 (D) sequences showing a compartmentalized cystic formation of the medial gastrocnemius muscle related to a mucoid cyst of the gastrocnemius muscle

Soft-tissue mucoid cysts on the periosteal surface, often found in contact with the posterior aspect of the inferior femoral metaphysis or on the anterior aspect of the tibia, can erode the cortical bone. If necessary, an MRI scan can be used to rule out a tumour lesion (figure 13).
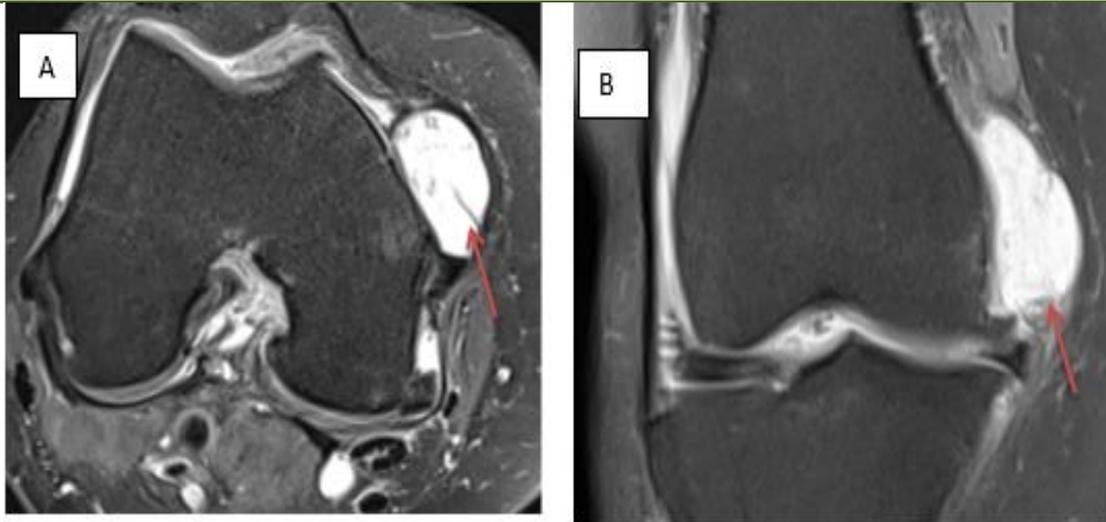
Figure 13: MRI of the knee in DP axial (A), sagittal (B), coronal (C) and T2 sagittal (D) sequences, showing a periosteal mucoid cyst
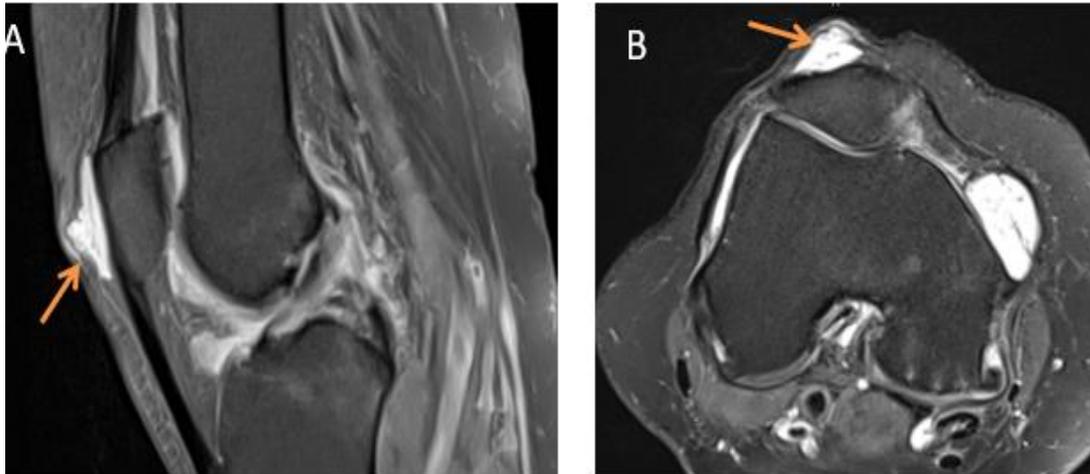
3-Bursitis
3.1. Anterior bursitis:
3.1.1- Pre-patellar bursitis

The prepatellar bursa is located anteriorly, between the patella and subcutaneous tissues, adjacent to the proximal patellar tendon. Prepatellar bursitis is inflammation of the prepatellar bursa following trauma (direct fall on the knee) or repetitive chronic microtrauma, often due to frequent kneeling and crawling. That's why this bursitis is called "maid's knee". On MRI, prepatellar bursitis presents as a fluid collection anterior to the patella and superior to the patellar tendon (figure 14). It presents a fluid signal on all MRI sequences. However, inflammation or haemorrhagic changes may alter its appearance into an ill-defined, compartmentalized collection with a heterogeneous signal and internal debris. (Beaman et Peterson, 2007; Janzen *et al.,* 1994; Krudwig *et al.,* 2004)

Figure 14: MRI of the knee, sagittal (A) and axial (B) sections, DP showing a fluid collection in the prepatellar fat in connection with prepatellar bursitis (arrow). Note a medial para-articular mucoid cyst

3.1.2. Suprapatellar Bursitis:

The suprapatellar bursa is located between the quadriceps tendon and the femur. It normally communicates with the synovial cavity of the knee, but may be isolated in the case of residual suprapatellar plica. The suprapatellar plica is a normal embryonic septum between the bursa and the joint, which usually perforates and regresses; however, it persists in around 20% of adult knees (Beaman et Peterson, 2007; Samim *et al.,* 2014; Wu et Hochman, 2009). It can vary from a minor transverse septum to a complete membrane separating the suprapatellar bursa from the joint cavity. Fluids accumulated in a non-communicating suprapatellar bursa appear as a mass above the knee joint (figure 15). MRI then shows a focal fluid collection anterior to the distal femur, possibly with a suprapatellar plica separating the bursa from the knee joint.

Figure 15: MRI of the knee in sagittal T1 (A), T2 (B) and axial T1 slices after injection of Gadolinium (C), showing a suprapatellar fluid collection, between the quadriceps tendon and the femur, peripherally enhanced after inuejction of Gadolinium in connection with suprapatellar bursitis

3.1.3- Infrapatellar bursitis :
3.1.3.1 Superficial infrapatellar bursitis :

The superficial infrapatellar bursa or pretibial bursa is located between the tibial tubercle and the overlying skin. It is a rare site of bursitis, but direct trauma or professional overuse (pastor's knee) can lead to inflammation and microhemorrhage. On MRI, a poorly limited fluid collection is usually found opposite the anterior tibial tuberosity (Figure 16 A) (Beaman et Peterson, 2007 ; Krudwig *et al.,* 2004 ; Wu et Hochman, 2009).

3.1.3.2 Deep infrapatellar bursitis :

The deep infrapatellar bursa is located between the posterior border of the distal part of the patellar tendon and the anterior surface of the tibia, beneath Hoffa's fat pad (Beaman et Peterson, 2007; Krudwig *et al.,* 2004; Wu et Hochman, 2009). This bursa does not communicate with the knee joint. It is generally inflamed during sports overuse, most commonly in runners and jumpers (Beaman et Peterson, 2007; Helfenstein et Kuromoto, 2010). On MRI, it appears as a fluid collection between the distal patellar tendon and the tibia; however, a small amount of fluid in the deep infrapatellar space may be present in asymptomatic individuals, so clinical assessment is always necessary (Figure 16 B).

Figure 16: MRI of the knee in DP sagittal section illustrating A : superficial infrapatellar bursitis and B deep infrapatellar bursitis

3.2- Medial bursitis
3.2.1- Crow's-foot bursitis :

This bursa is located along the medial aspect of the tibia, separating the tendons of the crow's-foot muscles (sartorius, gracilis and semitendinosus tendons) from the tibial insertion of the medial collateral ligament (MCL), slightly distal to the insertion of the semimembranosus tendon. Acute bursitis most often results from overuse, particularly in runners (McCarthy

et McNally, 2004 ; Helfenstein et Kuromoto, 2010). Chronic bursitis is common in elderly patients with degenerative joint disease or rheumatoid arthritis. On MRI, it appears as a collection along the medial aspect of the knee adjacent to the foot. The differential diagnosis is with para-meniscal cysts and synovial cysts, but the latter communicate with the knee joint, although this communication is not always perceptible (figure17)

Figure 17: MRI right knee: axial (A) and coronal (B) sections, proton density (PD) sequence showing a fluid collection (yellow arrow) of the medial aspect of the knee located between the medial collateral ligament (red arrow) and the crow's feet tendons: Sartorious, Gracile, Semitendinosus (green, red and orange stars respectively)

3.2.2-Medial collateral ligament (MCL) bursitis :

The bursa of the medial collateral ligament extends vertically between the superficial and deep layers of the MCL Isolated bursitis of the MCL is extremely rare; in most cases, it is associated with arthritis and pathologies of the medial compartment of the knee (osteoarthritis, trauma, etc.), which may lead to hemorrhagic remodeling of this bursa or rupture with ligament capsule communication (Beaman et Peterson, 2007; Anderson *et al.,* 2010; Wu et Hochman, 2009). On MRI, it appears as a vertically elongated, well-defined fluid collection between the superficial and deep layers of the MCL (figure 18). Differential diagnosis is required with meniscal and para-meniscal cysts, as well as mucoid cysts.
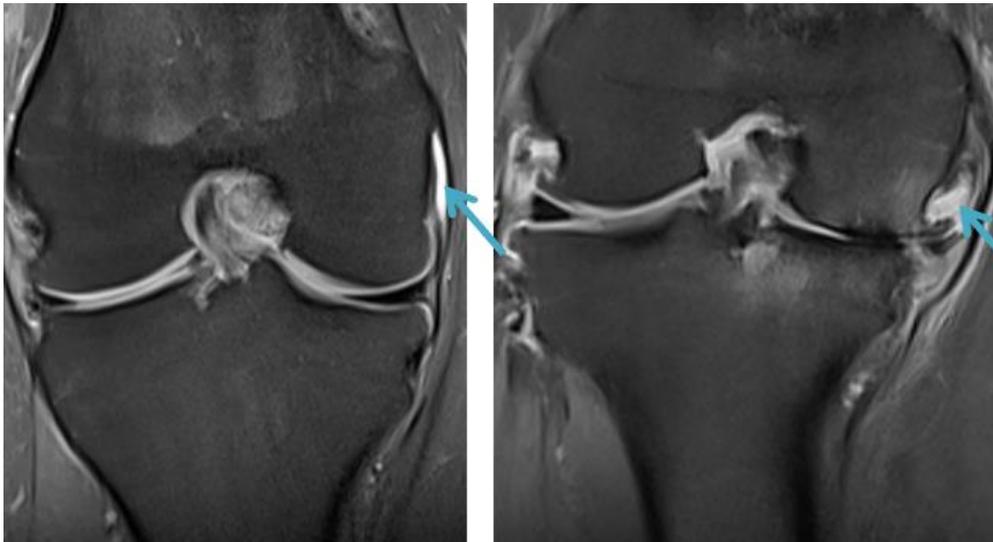

Figure 18: Coronal MRI of the knee showing MCL bursitis

3.2.3- Bursitis of the semimembranosus muscle:

The bursa of the semimembranosus muscle is situated between the semimembranosus tendon and the medial collateral ligament, with a deeper portion extending between the semimembranosus tendon and the medial tibial condyle. Repetitive or acute trauma to the semimembranosus tendon can lead to bursitis. On MRI (figure 19), this bursitis appears as a collection oriented along the plane of the semimembranosus tendon, which may surround the tendon, forming an inverted "U" image on axial images: the deep portion of this collection is located between the semimembranosus tendon and the medial tibial condyle. The superficial portion lies distally between the semimembranosus tendon and the medial collateral ligament. The two portions are joined superiorly along the anterosuperior edge of the semimembranosus tendon (Beaman et Peterson, 2007; Krudwig *et al.,* 2004; Yoon *et al.,* 2014).
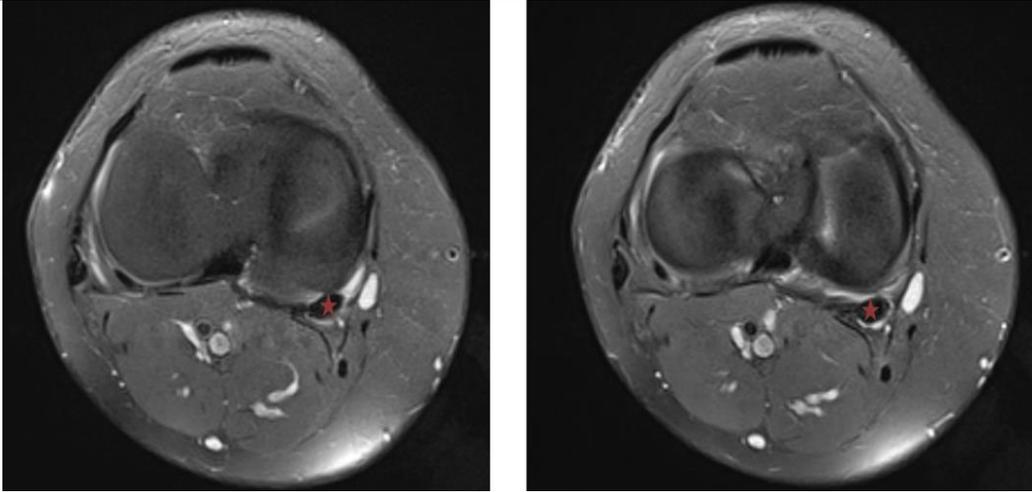
Figure 19: MRI right knee: DP axial sections showing a fluid collection on the medial side of the knee surrounding the tendon of the semimembranosus muscle (red star)
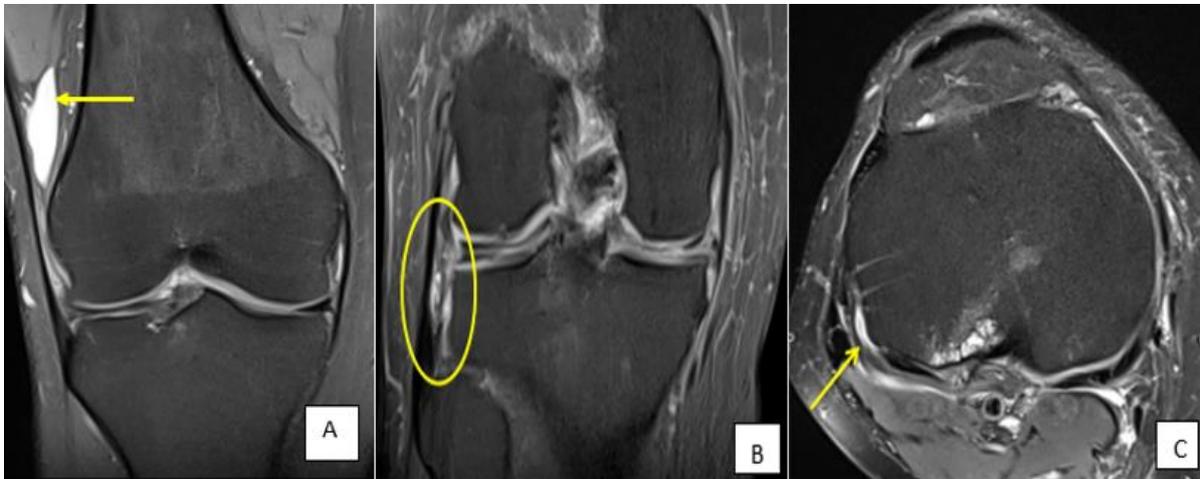
3.3-Lateral Bursitis :
3.3.1- Iliotibial Bursitis

The iliotibial bursa is located between the distal part of the iliotibial band, near its insertion on Gerdy's tubercle, and the surface of the adjacent tibial bone. On MRI, iliotibial bursitis appears as a well-defined fluid collection between the distal insertion of the iliotibial band and the adjacent bony surface (figure 20A). (Krudwig *et al.,* 2004; Wu & Hochman, 2009).

1.1.2.3.7 Bursitis of the biceps femoris / lateral collateral ligament :

The lateral collateral ligament-biceps femoris bursa is located between the lateral collateral ligament and the long portion of the biceps femoris (Beaman & Peterson, 2007; Vicentini & Chang, 2022). On MRI, this bursitis is seen as a fluid formation around the LCL in the shape of an inverted J in the axial plane: the long arm of the J is visible along the lateral aspect of the LCL, with the hook rotating around the anterior edge of the LCL (fig.20B).


Figure 20: A: Coronal MRI of the knee showing iliotibial bursitis. B and C: MRI knee in coronal (A) and axial (B) sections, proton density (PD) sequence showing a fluid collection (yellow arrow) on the lateral face of the knee located between the lateral collateral ligament in relation to bursitis

4-Pseudo-cysts of the knee

A variety of "pseudo-cystic" lesions can be encountered in and around the knee joint, which can further complicate the differential diagnosis (Marra *et al.,* 2008; Perdikakis et Skiadas, 2013; Shikhare *et al.,* 2018).

Aneurysms of the popliteal artery (figure 2) show variable signal intensity on MRI images, depending on flow characteristics and pulse sequences. They are generally located in the popliteal fossa and present continuity with the popliteal artery.
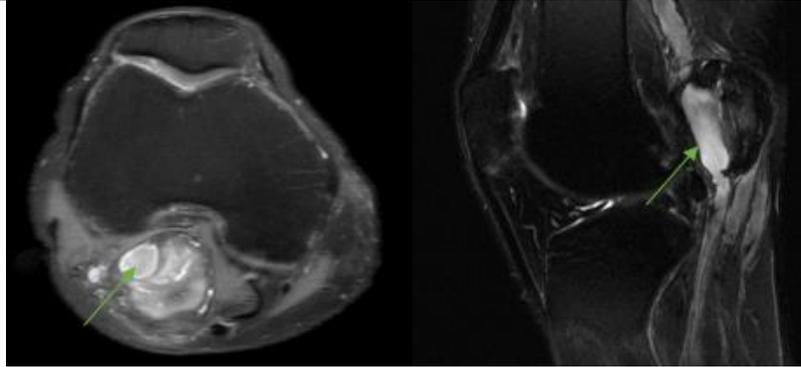
Figure 21: MRI in axial and sagittal DP sections showing a partially thrombosed aneurysm of the popliteal artery Deep and superficial varicose veins can also simulate cystic lesions in the popliteal fossae. They appear on MRI images as lobulated masses in continuity with the deep or superficial venous network

Hematomas can simulate a cyst (figure 22), but can be differentiated by their signal intensity, which varies according to the age of the blood products (hemoglobin degradation products).
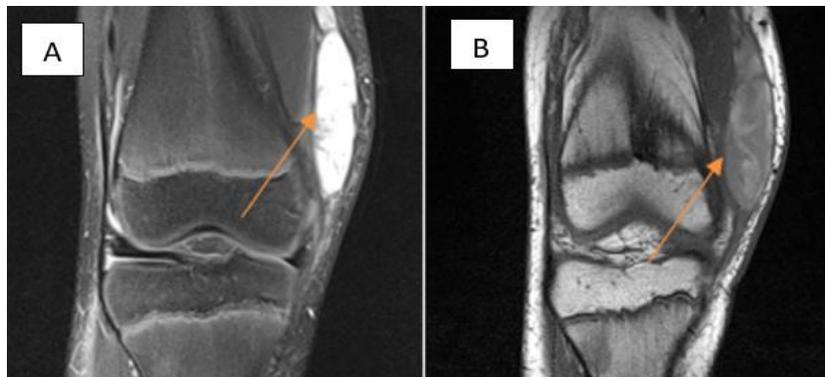
Figure 22: MRI of the knee in DP (A) and T1 (B) coronal sections showing a fusiform fluid collection on the medial side of the knee in T1 isosignal/T2 hypersignal in relation to a haematoma

Abscesses, which may also mimic cysts, may be encountered during infections around the knee. Gadolinium injection usually reveals characteristic enhancement, and can be used to search for fistulous tracts. Solid malignant tumors with necrosis, cystic degeneration or myxoid stroma, such as synovial sarcoma (figure 23), dedifferentiated sarcoma, myxoid liposarcoma and metastases, may also have a homogeneous fluid signal mimicking a cyst, but injection of contrast medium often leads to a malignant etiology in the case of suspicious contrast uptake or an enhanced fleshy portion.
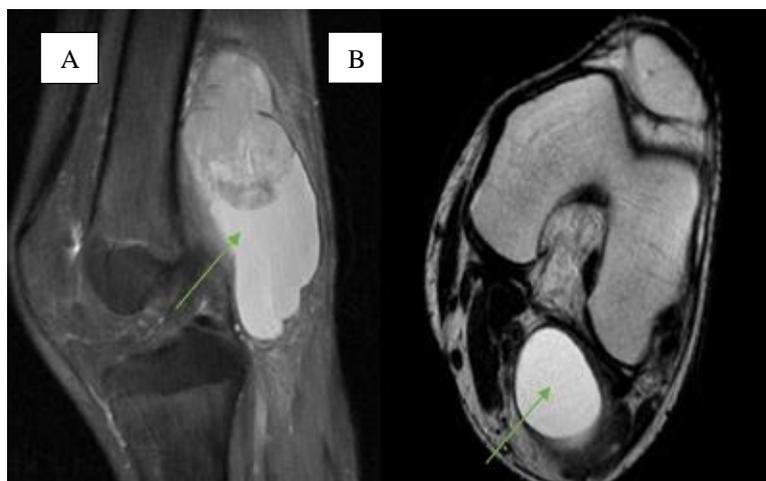
Figure 23: MRI of the knee in sagittal (A) and axial section showing a solid cystic formation in the right popliteal fossa in connection with a synovial sarcoma

B- Distribution of cystic lesions based on compartments

ANTERIOR COMPARTMENT
- Anterior bursitis
  - Pre-patellar bursitis
  - Suprapatellar bursitis
  - Superficial infrapatellar bursitis
  - Deep infra patellar bursitis
  - Meniscal cysts
- HOFFA fat mucoid cysts
- Intraosseous cysts.
- Mucoid cysts of soft tissue and periosteal surface

POSTERIOR COMPARTMENT
- Popliteal cyst
- Proximal tibiofibular joint cyst
- Intra-neural cyst
- Adventitial arterial cyst
- Intraosseous cyst.
- Mucoid cysts of soft tissue and periosteal surface

CENTRAL PIVOT
- Mucoid cyst of the cruciate ligaments
- Mucoid insertion cyst
- Intercondylar notch cyst

LATERAL COMPARTMENT
- Iliotibial bursitis
- Bursitis of the biceps femoris (LCL)
- Meniscal and para-meniscal cysts
- Mucoid cysts of soft tissue and periosteal surface

MEDIAL COMPARTMENT
- Medial crow's feet bursitis
- Medial cruciate ligament bursitis
- Bursitis of the semimembranosus muscle
- Meniscal and para-meniscal cysts

CONCLUSION

Cystic lesions around the knee are frequently observed on MRI exams. Their origins are variable. MRI is the modality of choice for identifying and characterizing these lesions. Radiologists need to be able to identify the typical MRI patterns that help establish a correct diagnosis and thus guide specific therapy and avoid unwarranted interventional procedures such as biopsy or arthroscopy. In the case of pseudocystic lesions, the use of intravenous injection of gadolinium aids diagnosis and helps differentiate them from cysts.

Conflict of Interest: None

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