

MRI Aspects of Knee Pathologies at Cheikh Ahmadoul Khadim National Hospital Center of Touba

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Abstract

Introduction: Imaging plays a central role in knee exploration. Due to its diagnostic performance and non-invasive nature, magnetic resonance imaging (MRI) is currently the first-line imaging modality after conventional radiology. **Objective:** The aim of our study was to describe the morphological aspects of lesions observed on MRI of the knee and to compare the semiological features of knee pathology between the two groups of patients with traumatic and non-traumatic lesions. **Material and Method:** We conducted a retrospective, descriptive cross-sectional study over 6 months in the Radiology and Medical Imaging Department of the National Hospital Center Cheikh Ahmadoul Khadim of Touba, including 48 patients who underwent MRI of the knee. The MRI protocol included DPFS weighted sequences in the 3 planes, T1 SE sagittal or coronal and T2 TSE sagittal in the plane of the ACL. In 1 patient, axial T1 FS sequences after gadolinium injection were performed. Data were entered and processed on SPSS version 22.0 software. Parameters studied were types and location of meniscal lesions, cruciate ligament ruptures, various chondropathy lesions, medullo-spongy edema, fractures and intra-articular effusion. **Results:** The mean age of the patients was 33.69 years, with extremes ranging from 14 to 69 years, and a M/F sex ratio of 4.33. Traumatic lesions accounted for 68.75%. The main reasons for MRI exploration were gonalgia (62.5%) and ligament laxity (25%). Meniscal lesions were found in 62.5% of patients, involving the medial meniscus in 73.3% and the lateral meniscus in 36.6%, located on the posterior horn (86.3% on the MM, 72.7% on the LM). Meniscus lesions were Stoller and Crues Grade 2 in 45.4% of the medial meniscus and Grade 3 fissures in 36.4% of the lateral meniscus. ACL lesions were found in 58.3% of patients, all occurring in a traumatic context, in association with PCL ruptures

in 21.4% of cases. A combination of ACL rupture and medial meniscus injury was found in 53% of ACL-injured cases. We found chondropathies in 15 patients (31.3%) and medullo-spongy edema in 22 patients (45.8%), and joint effusion in 16 patients (33.3%). **Conclusion:** MRI is currently the non-invasive examination of choice for exploring traumatic and non-traumatic knee pathology and for planning therapeutic strategy.

Keywords

MRI, Knee, Trauma

1. Introduction

The knee is a complex biomechanical structure. It is a weight-bearing joint that must reconcile two conflicting requirements: stability and mobility. It consists of two joint units contained within a common capsulo-synovial space: a bicondylar femorotibial joint and a trochlear femoropatellar joint.

As the joint surfaces are not perfectly congruent, stability is ensured by a powerful ligamentous, musculotendinous and meniscal system that increases joint congruence [1]. All of these structures can cause pathologies that are more or less debilitating and can be the site of traumatic injuries or chronic internal disorders.

Imaging plays a central role in the examination of the knee. Due to its diagnostic performance and non-invasive nature, magnetic resonance imaging (MRI) is currently the first-line imaging modality after conventional radiology. It is the examination of choice for investigating knee pathology and planning subsequent therapeutic strategy [2] [3].

The main objective of our study was to investigate the MRI semiological characteristics of knee lesions.

The specific objectives were to describe and analyze epidemiological data, the locations and types of meniscal lesions, complete and partial tears of the cruciate ligaments, associated lesions, and to describe non-traumatic lesions.

2. Materials and Methods

This was a retrospective, descriptive study conducted over a period of 6 months (1 April to 30 September 2023) in the Radiology and Medical Imaging Department of the Cheikh Ahmadoul Khadim National Hospital Centre in Touba, including all patients who underwent knee MRI scans for any reason.

Patients with a history of knee surgery and patients with normal MRI scans were not included.

The equipment used was a 1.5 Tesla SIGNA Creator MRI manufactured by GENERAL ELECTRIC.

The MRI protocol included the following sequences in 3 mm slices without contrast agent injection:

- Proton density-weighted sequences with fat signal saturation (DPFS) in three planes (axial, sagittal and coronal).
- Spin echo (SE) sequences with T1 weighting (sagittal or coronal).
- T2-weighted TSE sequences in the anterior cruciate ligament plane (sagittal).
- Axial and sagittal T1 FS sequences after gadolinium injection were performed in one patient.

For all patients, an individual form was completed to collect the following parameters:

- Epidemiological data.
- History of knee trauma.
- Clinical data.
- Location and type of meniscal lesions.
- Cruciate ligament lesions.
- Lateral ligament lesions.
- Medullo-spongy oedema.
- Chondropathy.
- Fracture.

The data were entered and processed using SPSS version 22.0 software.

Qualitative variables were described using observed numbers and frequencies (%). Quantitative variables were described using means and standard deviations.

3. Results

The 48 patients were divided according to the context of the injury:

- Traumatic (n = 33, or 68.7%).
- Non-traumatic (n = 15, or 31.2%).

3.1. Epidemiological Data

Age: The average age was 33.69 years, ranging from 14 to 69 years.

It was 31.3 years in traumatic cases and 38.93 years in the group of patients with no history of trauma (**Table 1**).

Table 1. Average age of patients according to lesion context.

	Total (n = 48)	Non-traumatic (n = 15)	Traumatic (n = 33)	P
Average	33.69 ± 13.006	38.93 ± 15.91	31.3 ± 10.9	0.059
Min. - Max.	14 - 69	14 - 69	18 - 57	

Gender: There were a total of 39 men (81.3%) and 9 women (18.8%), giving a sex ratio of 4.33.

The sex ratio was 7.25 in cases of trauma and 2 in cases without trauma.

3.2. Clinical Data

Gonalgia was present in 62.5% of patients. Instability was noted in 15.2% of patients

admitted for trauma and 13.3% of patients with no history of trauma. The distribution of patients according to indications is shown in **Table 2**.

Table 2. Frequency of clinical signs observed according to the context of the injury.

	Total (n = 48)	Non traumatic (n = 15)	Traumatic (n = 33)
Knee pain	30 (62.5%)	10 (66.7%)	20 (60.6%)
Swelling	4 (8.3%)	3 (20%)	1 (3%)
Instability	7 (14.6%)	2 (13.3%)	5 (15.2%)
Ligament laxity	12 (25%)	3 (20%)	9 (27.3%)
Anterior drawer test	11 (22.9%)	0 (0%)	11 (33.3%)
Locked knee	3 (6.3%)	3 (20%)	0 (0%)
Mass	2 (4.2%)	2 (13.3%)	0 (0%)

3.3. MRI Data

Meniscal lesions: Meniscal lesions were observed in 30 patients (62.5%), 70% of whom had suffered trauma and 30% of whom had not. They accounted for 63.6% of all traumatic lesions (**Table 3**).

Table 3. Frequency and distribution of meniscal lesions according to the context of the injury.

	Total (n = 48)	Non-traumatic (n = 15)	Traumatic (n = 33)
Meniscal lesions	30 (62.5%)	9 (60%)	21 (63.6%)
	(n = 30)	(n = 9)	(n = 21)
Medial meniscus (MM)	19 (63.3%)	7 (77.8%)	12 (57.1%)
Lateral meniscus (LM)	8 (26.7%)	2 (22.2%)	6 (28.6%)
MM + LM	3 (10%)	0 (0%)	3(14.3%)

Medial meniscus: Medial meniscus injuries were observed in 22 patients (45.8%) and accounted for 73.3% of meniscus injuries, with 68.2% occurring in cases of trauma and 31.8% in the absence of trauma (**Table 4**).

Inner meniscus injuries affected the anterior horn in 13.6% of cases, the posterior horn in 81.8% and the AH + PH in 4.5% of cases.

Stoller and Crues Grade 2 tears accounted for 45.4% of inner meniscus injuries and 53.3% of traumatic injuries.

Grade 3 tears were noted in 18.2% of all medial meniscal lesions, all of which occurred in a traumatic context (26.6%) (**Figure 1**). One case of meniscal flap was noted (**Figure 2**).

External meniscus: External meniscal lesions were observed in 11 patients (22.9%) and 36.7% of meniscal lesions, traumatic in 81.8% (n = 9) and non-traumatic in 18.2% (n = 2).

External meniscal lesions located at the posterior horn were found in 63.7% of cases, all of which were traumatic in nature.

Table 4. Characteristics of internal meniscal lesions (location and type) according to the context of the injury.

MM lesions	Total (n = 22)	Non-traumatic (n = 7)	Traumatic (n = 15)
Location			
Anterior horn	3 (13.6%)	1 (14.3%)	2 (13.3%)
Posterior horn	18 (81.8%)	6 (85.7%)	12 (80%)
AH + PH	1 (4.5%)	0	1 (6.7%)
Type of lesions			
Grade 2 tear	10 (45.4%)	2 (28.6%)	8 (53.3%)
Grade 3 tear	4 (18.2%)	0 (0%)	4 (26.6%)
Meniscal flap	1 (4.5%)	1 (14.3%)	0 (0%)
Contusion	1 (4.5%)	0 (0%)	1 (6.6%)
Degeneration	4 (18.2%)	3 (42.8%)	1 (6.6%)
Dislocation	1 (4.5%)	1 (14.3%)	0 (0%)
Disinsertion	1 (4.5%)	0 (0%)	1 (6.6%)



Figure 1. 24-year-old patient admitted for post-traumatic knee pain; sagittal DPFS MRI showing a vertical meniscal tear with hypersignal in the posterior horn of the medial meniscus, extending to the upper and lower meniscal articular facets: Grade 3 tear (red arrow).



Figure 2. 60-year-old patient admitted for left meniscal syndrome. Coronal DPFS scan showing a meniscal tear of the medial meniscus (red arrow) with oedema of the corresponding tibial plateau (yellow arrow).

These lesions were distributed as follows: 4 Grade 3 lesions according to Stoller and Crues, representing 36.4% of all lateral meniscus lesions and 44.4% of traumatic lesions, 3 Grade 2 lesions, corresponding to 27.2% and 33.3% of traumatic lesions, one meniscal contusion lesion and one bucket-handle lesion (**Figure 3**). Non-traumatic lesions were divided into degeneration and meniscal dislocation.

With a bucket handle tear (yellow arrow), this is accompanied by a partial rupture of the PCL (red arrows).



Figure 3. 57-year-old patient admitted for severe sprain of the right knee. Sagittal slices in DPFS showing a longitudinal tear in the posterior horn of the external meniscus displaced at the joint, giving the appearance of a double posterior cruciate ligament associated with a bucket handle tear (yellow arrow). This is accompanied by a partial rupture of the PCL (red arrows).

Ligament injuries:

Cruciate ligaments:

ACL injuries: Anterior cruciate ligament ruptures were found in 28 patients (58.3%), 93% of which were traumatic in nature. The rupture was complete in 13 patients (46.4%) (**Figure 4**). A partial rupture was diagnosed in 15 patients (53.6%) (**Figure 5**).

PCL injuries: Six cases of posterior cruciate ligament rupture were observed, all in association with traumatic ACL ruptures. The rupture was partial in 5 patients (83.3%) (**Figure 6**) and complete in 1 patient (16.7%).

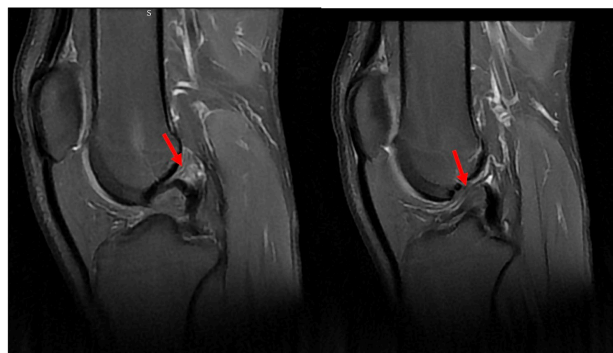


Figure 4. 20-year-old patient admitted for right knee pain following trauma. Sagittal slices in DPFS showing complete rupture of the ACL, not visible in its position (red arrow).

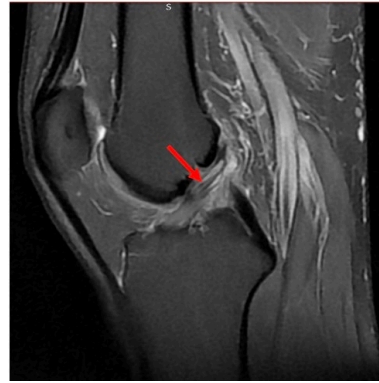


Figure 5. 35-year-old patient with clinical signs of anterior drawer syndrome and post-traumatic ligament laxity in the right knee. Sagittal DPFS scan showing partial rupture of the ACL (red arrow).

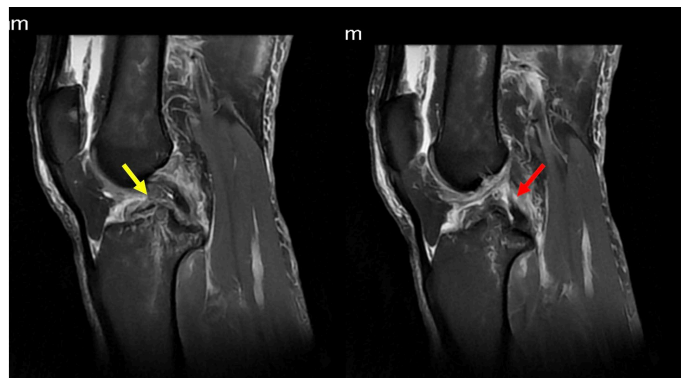


Figure 6. 24-year-old patient admitted for severe sprain of the left knee.

Lateral ligaments: Lateral ligament ruptures were present in 5 patients (10.4%), affecting the medial collateral ligament in 2 cases (40%), the lateral collateral ligament in 1 patient (20%) and both lateral ligaments in 2 patients (40%).

Medullo-spongiosa oedema: Medullo-spongiosa oedema was observed in 22 patients (45.8%) and was found in 48.5% of cases of traumatic injury. The location at the external femoral condyle accounted for 40.9% (**Figure 7**).

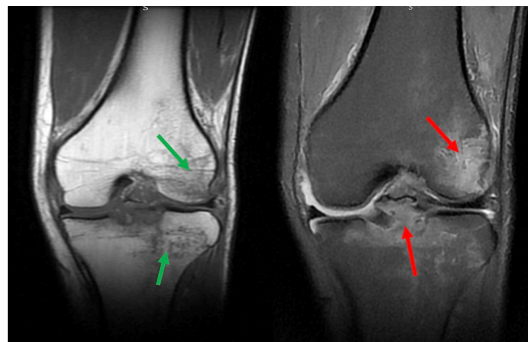


Figure 7. 30-year-old patient admitted for severe sprain of the left knee. Coronal T1 and coronal DPFS slices showing medullo-spongiosa oedema mirroring the external femoral condyle and external tibial plateau with low signal intensity on T1 (green arrow) and high signal intensity on DPFS (red arrows).

Chondropathy: Cartilage lesions were observed in 15 patients (31.3%). Type 3 chondrolysis accounted for 40% of all cartilage lesions (**Table 5**).

Table 5. Frequency and type of chondropathies.

Type	Effective	Percentage (%)
Type 1 chondrolysis	1	6.6
Type 2 chondrolysis	4	26.7
Type 3 chondrolysis	6	40
Type 4 chondrolysis (Figure 8)	4	26.7

Fractures: They were observed in 6 patients (12.5%), involving the tibia in 3 patients (50%), the patella in 1 patient (16.7%) (**Figure 9**) and the femur in 2 patients (33.3%).

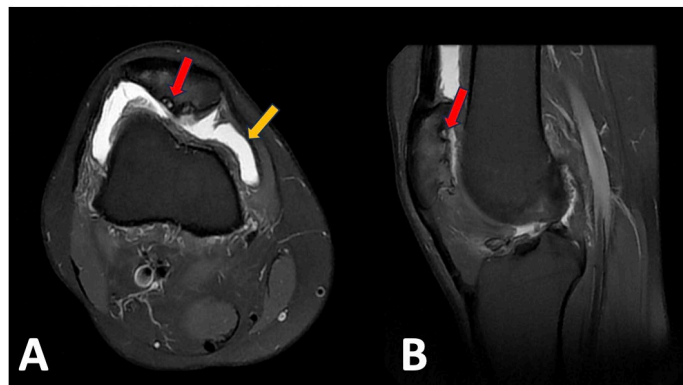


Figure 8. 37-year-old patient admitted for pain and swelling in the right knee. Axial (A) and sagittal (B) slices in DPFS showing femoropatellar arthrosis with Grade 4 chondrolysis at the patella (red arrow) with joint effusion (yellow arrow).



Figure 9. Sagittal DPFS section of a 23-year-old patient admitted for trauma to the left knee, showing a complete fracture of the patella with patellar bone oedema.

Other lesions: Joint effusion was noted in 16 patients (33.3%) and a popliteal

cyst was observed in 5 patients (10.4%). One case (2.1%) of tumour was noted in cases of non-traumatic lesions.

4. Discussion

4.1. Epidemiological Data

In line with recent studies [4]-[6], our population is relatively young, with an average age of 33.69 years and extremes ranging from 14 to 69 years.

Epidemiological analysis shows a younger average age for traumatic injuries (31.3 years) compared to non-traumatic injuries (38.93 years), which could reflect a more active population and therefore one that is more susceptible to physical trauma. The relatively young population can be explained by the fact that these injuries are linked to high-energy trauma, which is more common in young adults [7].

We noted a marked male predominance in both categories with a sex ratio of 4.33, particularly in the case of traumatic injuries (sex ratio of 7.25), compared to non-traumatic injuries (sex ratio of 2). This observation is consistent with previous studies that have suggested that men are more prone to high-energy trauma due to intensive physical or sporting activities [7].

4.2. Clinical Data

The reliability of clinical examination drops significantly in cases of multiple lesions, falling from 70% for single lesions to 30% for multiple lesions [8]. Clinically, signs such as instability, ligament laxity and joint locking showed different trends between the groups, with, for example, a higher frequency of locking in non-traumatic lesions in our study. This could reflect the nature of the underlying pathologies in the two categories, where traumatic injuries are more likely to cause instability due to ligament ruptures, while non-traumatic injuries could lead to blockages due to meniscal degeneration or cyst formation.

In our series, 62.5% of patients were referred for persistent knee pain, followed by ligament laxity as the second reason for exploration with 25% and anterior drawer syndrome in 22.9%; these results are consistent with the literature, where knee pain was the most consistent functional sign [9].

4.3. MRI Data

Meniscal lesions: In the literature, the sensitivity of MRI for detecting meniscal lesions varies between 80% and 98%, and its specificity between 57% and 98% [3] [10]. These figures vary depending on the meniscus, with better sensitivity for the medial meniscus and better specificity for the lateral meniscus [11].

In our series, 30 patients (62.5%) had meniscal lesions, with a clear predominance of medial meniscus lesions at 73.3%.

Stoller and Crues Grade 2 lesions accounted for 45.4% of medial meniscus lesions, 53.3% of which were traumatic.

Meniscal degeneration was found in 18.2% of medial meniscus lesions, 75% of

which were non-traumatic, and affected the lateral meniscus in 9.1% of cases without a non-traumatic context.

Grade 3 lesions accounted for 36.4% of lateral meniscus lesions, all in a traumatic context. These lesions are symptomatic and are considered to be true traumatic lesions.

The distribution of meniscal lesions is consistent with the data in the literature, with the medial meniscus being affected more frequently [12]. This is the same finding as that of Yekpe *et al.* [13] and Messaoudi [14], who found 67.79% and 67% of lesions to be in the medial meniscus, respectively.

This is often attributed to anatomical and functional differences between the two menisci. The medial meniscus is firmly attached to the tibia, particularly the posterior horn [15]. This tight attachment locks the medial meniscus between the femoral condyle and the medial tibial plateau and exposes it to different forces and injury mechanisms compared to the lateral meniscus. The latter is more loosely attached to the tibial plateau, which allows it to be very mobile and less exposed to compressive forces than the medial meniscus [16].

As for the location of meniscal lesions, several series reported in the literature have shown that lesions most often affect the posterior horn [17]-[19]. In line with the literature, we found a predominance of posterior horn involvement, with 86.3% in the medial meniscus and 72.7% in the lateral meniscus. This could be explained by the vulnerability of the posterior horn of the medial meniscus and the fact that it is thicker than the rest of the meniscus, which leads to a decrease in the diffusion of synovial fluid at this level, thus accelerating the onset of degenerative changes and weakening of the posterior horn [20]. Suganuma [21] studied the relationship between posterior medial incongruity of the femorotibial joint in knee hyperflexion and meniscal lesions. He concluded that this incongruity increases hyperpressure in the posterior horn of the medial meniscus and exposes it to lesions.

This part of the meniscus is therefore the most affected because it is also subject to torsion, rotation and compression during valgus flexion and external rotation, which is the mechanism most often implicated in knee injuries [22]. Apart from this aspect, the posterior horn, especially that of the medial meniscus, is the part most affected by the instability that occurs following ACL ruptures.

Central pivot injuries:

ACL injuries: MRI is a reliable diagnostic tool for ACL tears, with sensitivity ranging from 92% to 96% and specificity from 92% to 99% depending on the study [23].

The ACL is composed of two main functionally different components, the posterolateral and the anteromedial. The latter is usually the first to fail and may be the only one [24]. On examination, the traumatic mechanism may preferentially affect one bundle, the anteromedial in flexion and the posterolateral in extension.

The ACL is frequently subjected to excessive stress due to its anatomical posi-

tion and also because it is a much less resistant ligament. In addition, ACL rupture often occurs in valgus flexion with external rotation, which is the most common mechanism of severe knee sprains [22].

In our study, we identified ACL tears in 28 patients (58.3%), occurring in 93% of cases in a traumatic context, 53.6% of which were partial tears. This difference could be explained by the use of thin sagittal oblique sections in the ACL axis, which significantly improves the identification of partial tears.

Lesions associated with ACL tears include bone contusions, fractures, meniscal lesions, anterior tibial subluxation and other ligament injuries.

These indirect signs of ACL rupture are especially useful when it is difficult to reach a conclusion based on direct signs alone. They confirm the rupture (good specificity) but cannot rule it out if they are absent (low sensitivity).

ACL injury combined with medial meniscus injury was found in 53.6% of our patients. The literature reports an incidence of medial meniscus tears of approximately 60% in cases of ACL rupture [25]. Indeed, the hyperlaxity induced by ACL rupture is responsible for medial meniscus injuries. In some cases, ACL injury is concomitant with medial meniscus injury. The latter acts as a secondary stabiliser to anterior translation of the tibia and supports increased stress in cases of ACL deficiency. In the presence of chronic ACL lesions, the proportion of medial meniscus lesions can reach 90% - 98% [25].

PCL injuries: PCL injuries are less common than ACL injuries because the PCL is approximately 1.3 to 2 times thicker and 2 times stronger, and therefore less frequently subjected to excessive stress [26].

The main mechanism of injury is posterior translation of the tibia on a flexed knee (dashboard position), less often forced hyperextension.

The incidence of PCL injuries reported in the literature varies [27]. In our series, PCL injuries were found in 6 patients (12.5%), all occurring in association with ACL ruptures and in a traumatic context. It should be noted that partial tears constituted the majority of these injuries (83.3%).

In the chronic stage, PCL rupture results in variations in ligament thickness, a distended appearance and peri-ligamentary scarring. However, at this stage, MRI becomes less reliable. Due to its extensive vascularisation, the PCL can heal and appear morphologically normal on MRI but still be functionally ruptured. It is therefore sometimes possible to obtain normal imaging, with fibre continuity, even though clinical instability is present.

Servant *et al.* [28] found in their study that the reliability of MRI was reduced to 57% for the diagnosis of chronic PCL lesions.

Other injuries: Knee injuries other than meniscal and ligament injuries are common. The most common in our series were chondropathies (31.3%), which were present in 66.7% of non-traumatic injuries, and medullary-spongy oedema (45.8%), 48.5% of which were found in traumatic contexts.

The analysis of these injuries is interesting because it provides information on the mechanism of injury and allows other signs that may accompany the different

types of injuries to be investigated.

For chondropathy injuries, MRI plays an important role in their assessment, allowing cartilage abnormalities to be visualised that are not always apparent on conventional X-rays.

Chondropathy can result mainly from degenerative or inflammatory processes. It manifests itself on MRI as surface irregularities, gradual thinning of the cartilage with areas of inhomogeneous signal, and even almost complete loss of cartilage, visible as areas of very low signal on all MRI sequences.

Specific analysis of cartilage has led some teams to use complementary sequences, in particular T1-weighted 3DFT gradient echo sequences with transverse magnetisation cancellation and fat signal suppression [29]-[31]. These sequences provide millimetre-thick contiguous slices in which only the cartilage shows a hypersignal.

The changes undergone by the cartilage make it less able to absorb stress, which then becomes excessive for the subchondral bone. The medullary oedema visible on MRI could reflect increased bone metabolism or bone damage due to microcracks occurring in weakened bone. One of the mechanisms involved in the formation of subchondral cysts may also be implicated, namely the passage of synovial fluid into the subchondral bone through cartilage fissures, which increases the amount of fluid in the medullary spaces [32].

In the absence of trauma, medullary oedema is often indicative of metabolic, infectious or inflammatory diseases affecting the bone.

The prevalence of medullary oedema on MRI in knee osteoarthritis is estimated at 60% - 80% [32]. Medullary oedema appears as a poorly defined area with low signal intensity on T1-weighted images and high signal intensity on T2-weighted images, with signal abnormalities through which normal structures remain visible. It can be mild (diameter less than 5 mm), moderate (diameter between 5 mm and 2 cm), or severe (diameter greater than 2 cm). Sometimes, medullary oedema accompanies a subchondral line with low T1 and T2 signal intensity, corresponding to a fissure.

Like any scientific work, our study had certain limitations, namely the retrospective nature of the survey, particularly with regard to data collection, and the relatively small sample size ($n = 48$).

5. Conclusion

Knee injuries are very common and heterogeneous, requiring effective and reliable diagnosis in order to establish an appropriate treatment plan. MRI is currently the gold standard for knee examination. In our study, traumatic injuries were predominant (68.75%), affecting young subjects, mainly males, with a sex ratio of 4.33 for all patients and 7.25 for patients with trauma. Meniscal injuries were more common (62.5%), affecting the medial meniscus in 73.3% of cases. ACL injuries were present in 58.3% of patients, 93% of whom had suffered trauma, and PCL ruptures were present in 21.4% of cases. Chondropathies were the most common non-traumatic injuries, accounting for 66.7% of cases.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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