


# Injury Pattern on Magnetic Resonance Imaging of First-time Patellar Dislocations in Children and Adolescents

## *Patrones de lesión en resonancia magnética de un primer episodio de luxación patelar en niños y adolescentes*

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### Abstract

**Objective** To characterize medial patellofemoral ligament (MPFL) lesions and osteochondral lesions after a first episode of lateral patellar dislocation (LPD) in young patients.

**Methods** We evaluated 91 magnetic resonance imaging scans from patients under 18 years of age (average age: 14.5 years), with a first episode of LPD, from a single pediatric emergency center, between 2008 and 2012. The location and extension of the MPFL lesions and the location and size of the osteochondral lesions were analyzed.

**Results** We found MPFL injuries in 49.5% (45) of the cases. Total and partial ruptures of the MPFL were found in 10.9% (10) and 39.5% (36) of the patients respectively. Among the total ruptures, 70% (7) occurred in the patellar insertion, 20% (2), in the femoral insertion, and 10% (1) were multifocal. Of the partial injuries, 72% (26) were patellar, 19.4% (7), femoral, and 8.3% (3), multifocal. Osteochondral lesions were found in 38% (35) of the patients; 62.8% (22) were located in the patella, and 34.2% (12), in the lateral femoral condyle, while only 3% (1) were multifocal.

**Conclusion** Half of the cases presented MPFL injuries. Partial MPFL injuries at the patellar attachment are the most common pattern in skeletally-immature patients suffering an LPD for the first time. More than one third of the cases of first-time LPD in children will present a concomitant osteochondral injury, mostly at the patella.

**Level of Evidence** Level III.  
adolescents

### Keywords

- ▶ lateral patellar dislocation
- ▶ medial patellofemoral ligament
- ▶ osteochondral injury
- ▶ children

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## Resumen

**Objetivo** Caracterizar las lesiones de ligamento patelofemoral medial (LPFM) y las lesiones osteocondrales luego de un primer episodio de luxación patelar (LP) en pacientes jóvenes.

**Métodos** Se evaluaron un total de 91 resonancias magnéticas de pacientes menores de 18 años (edad promedio: 14,5 años), con un primer episodio de LPL, en un único centro, entre 2008 y 2012. Se analizaron la ubicación y la extensión de la lesión del LPFM, y la ubicación y el tamaño de las lesiones osteocondrales.

**Resultados** Se encontraron lesiones del LPFM en el 49,5% (45) de los casos, y se observaron roturas totales y parciales del LPFM en el 10,9% (10) y el 39,5% (36), respectivamente. De las roturas totales, el 70% (7) fueron en la inserción rotuliana, el 20% (2), en la inserción femoral, y el 10% (1), multifocales. De las lesiones parciales, el 72% (26) fueron rotulianas, el 19,4% (7), femorales, y el 8,3% (3), multifocales. Las lesiones osteocondrales se encontraron presentes en el 38% (35) de los casos; el 62,8% (22) se localizaron en la rótula y el 34,2% (12) en el cóndilo femoral lateral, mientras que solo el 3% (1) fueron multifocales.

**Conclusión** La lesión del LPFM se encontró en la mitad de los casos de nuestra muestra, y, de los casos de lesiones parciales, la inserción rotuliana es el patrón más común en pacientes esqueléticamente inmaduros que presentan una LP por primera vez. Más de un tercio de los niños con LPL por primera vez tendrá una lesión osteocondral concomitante, principalmente en la rótula.

**Nivel de Evidencia** Nivel III.

## Palabras Clave

- ▶ luxación patelar
- ▶ ligamento patelofemoral medial
- ▶ lesión osteocondral
- ▶ niños
- ▶ adolescentes

## Introduction

Lateral patellar dislocation (LPD) is one of the most common knee injuries, and it corresponds to the main cause of hemarthrosis in adolescents.<sup>1,2</sup> A recent population-based study<sup>3</sup> found that the annual incidence of LPD is of 23.2 per 100 thousand people per year, and that dislocations occur more frequently among patients aged 14 to 18 years. Most of them occur during sports activities, after a valgus movement with axial load and rotation with the knee extended.<sup>3</sup>

The risk of recurrence varies from 30% to 70%, and repeated episodes increase the risk of persistent knee pain and degenerative changes in the joint.<sup>2,4</sup>

Patellofemoral joint stability depends on the complex interplay between active, passive, and static stabilizers that limit patellar displacement through the entire range of motion. The medial patellofemoral ligament (MPFL) has gained relevance in recent years, being recognized as the main passive stabilizer of lateral translation of the patella in the first 30° of flexion.<sup>5</sup> Injuries to the MPFL occur in 84% to 100% of the first episodes based on previous magnetic resonance imaging (MRI) studies,<sup>6-8</sup> and they are recognized as a relevant risk factor for its recurrence.

The MRI is a valuable diagnostic tool in the context of acute LPD.<sup>9,10</sup> It can facilitate the diagnosis in pediatric patients who are often unaware that they have suffered a dislocation and present an acute trauma to the knee that limits clinical examination. The characteristic MRI findings in cases of LPD include joint effusion, bone edema in the lateral femoral condyle and medial patella, and MPFL injury, among others.<sup>11,12</sup> In addition, the MRI provides additional

information on the associated pathologies (capsular, ligamentous, chondral, and osteochondral lesions) and the underlying joint morphology that may predispose to future instability.<sup>6,12,13</sup>

Osteochondral and MPFL injury patterns after LPD have not been well defined for the pediatric population, since most studies<sup>6-8</sup> encompass mixed cohorts of children and adults. However, several studies<sup>1,14,15</sup> suggest the existence of differences in the patterns between both groups. The location and extent of the MPFL lesion has significant clinical value regarding both treatment and prognosis. Therefore, an adequate characterization of MPFL injury patterns is essential.

The objective of the present study is to evaluate through MRI scans the patterns of MPFL lesions and osteochondral lesions in children and adolescents after a first episode of LPD.

## Materials and methods

We conducted a retrospective cohort study of all children and adolescents who presented a first-time acute LPD in a single pediatric emergency department between 2008 and 2012. The inclusion criteria were: a) patients aged 18 years or younger presenting with a clinical history and physical examination consistent with a first-time acute LPD; and b) MRI examination confirming an acute patellar dislocation (joint effusion pattern and bone marrow edema secondary to osteochondral impaction of the lateral femoral condyle against the medial aspect of the patella). Patients with

previous dislocations, previous knee surgeries, congenital dislocations, or clinical findings incompatible with acute LPD were excluded.

The medical records were reviewed to obtain demographic data (age, gender, laterality), the mechanism of injury, and data on participation in sports (preinjury Tegner activity score).

### MRI technique

Patients underwent imaging scans within the first two weeks of the dislocation, with the knee in full extension. All MRI examinations were performed on 1.5-T or 3.0-T scanners (1.5T Signa [GE Healthcare, Chicago, IL, US] with an 8-channel coil or a MAGNETOM Skyra 3T [Siemens Healthineers AG, Erlangen, Germany] with a 15-channel coil).

### Imaging evaluation

The images were retrospectively analyzed by two independent evaluators, a knee surgeon and a radiologist, both with more than ten years of experience, and the final decision was made through consensus. The MPFL was assessed according to a previously-reported method using coronal, axial, and sagittal views of T2-weighted images.<sup>7,8</sup>

The MPFL was divided into three regions: femoral attachment, intrasubstance, and patellar attachment. The fiber status of the MPFL was defined as normal, partial injury, or complete injury. Complete injury was defined as complete fiber disruption and subsequent extensive edema (→ Fig. 1, 2), while partial lesion was defined as an incomplete discontinuity with intraligamentous edema, in which some MPFL fibers could be identified in continuity (→ Fig. 3, 4). If osteochondral lesions were observed, their location and size in millimeters were described based on the largest cross-sectional measurement of the lesion.

## Results

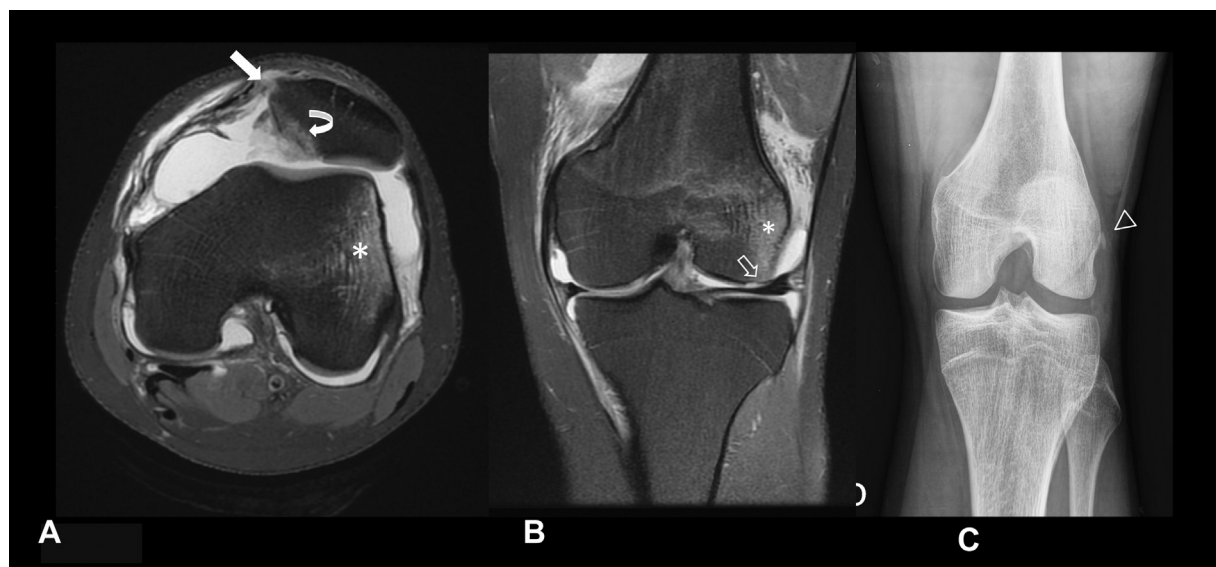
The total sample was composed of 91 patients (60 men and 31 women) who met the aforementioned inclusion criteria, and 50 right knees and 41 left knees were available for study. The mean age was 14.5 years (range: 11 to 18 years), with a mean preinjury Tegner activity score of 6 (range: 5 to 7). 64 patients practiced sports at the time of the injury (70.3%,  $n = 64$ ), and only 27 (29.7%) patients presented dislocation while performing their daily-life activities (walking, sitting, squatting or going down a staircase).

Indirect trauma was the main cause of injury, affecting 80.2% (73) of the patients, while direct injury was only observed in 19.7% (18) cases. Only 10 cases (11%) required manually-assisted reduction by an emergency physician, as most lesions reduced spontaneously.

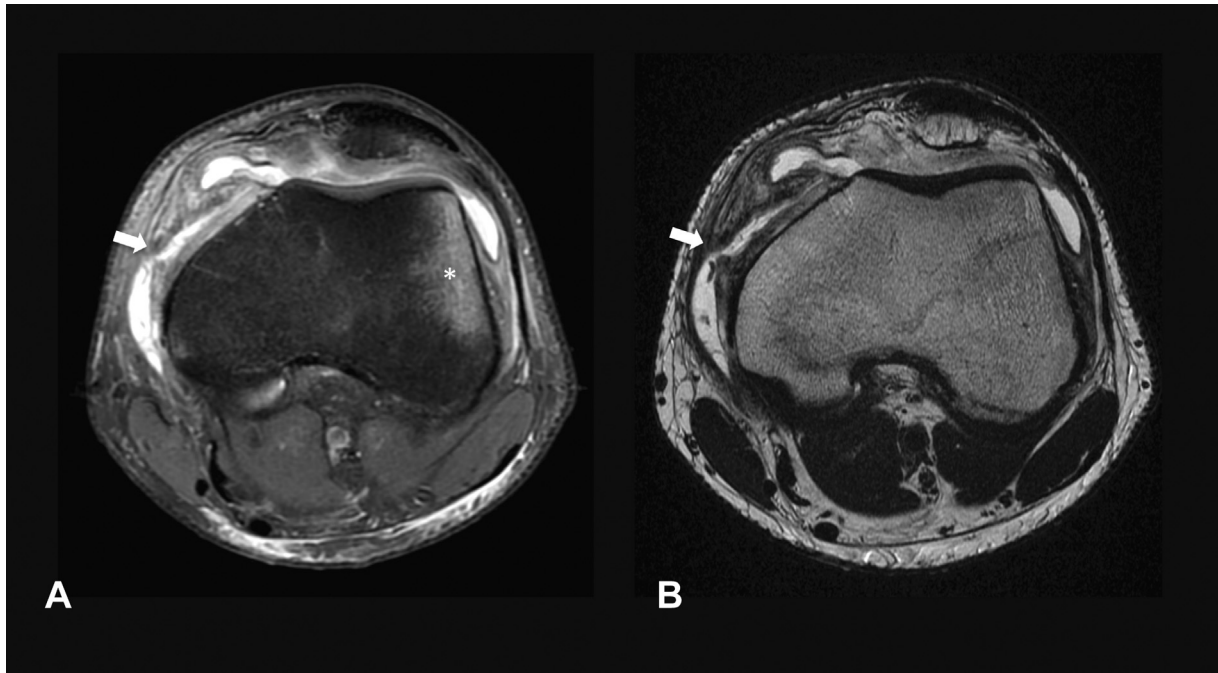
All MRI scans in the present series showed varying degrees of joint effusion, medial retinacular edema, and bone hematoma pattern reflected on the medial patellar facet and lateral femoral condyle, consistent with acute LPD. Lesions to the MPFL, either total or partial, were found in 46 cases (50.5%). The other 49.5% of the cases presented intra- and periligamentous edema, but there was no evidence of rupture of the MPFL fibers. In total, 36 cases (39.5%) presented partial MPFL lesions, while the other 10 cases (10.9%) presented complete lesions.

The location and extent of MPFL lesions are summarized in table 1. The partial lesions were located mainly in the patellar insertion (26 cases), followed by 7 cases in the femoral insertion, and 3 cases with multifocal partial tears. No partial injury was exclusively intrasubstance.

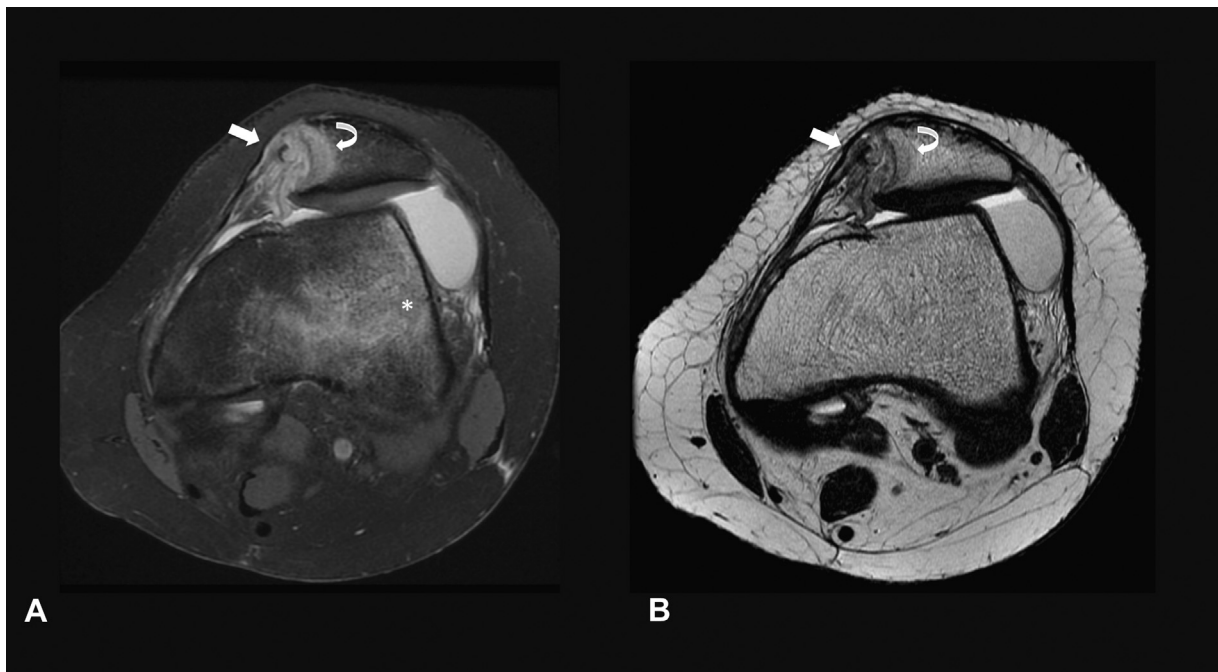
The complete lesions were also patellar in most (7) cases, followed by 2 cases of lesion in its femoral insertion, 1 case of



**Fig. 1** Axial proton-density weighted with fat saturation (PD fat sat) view showing (A) complete rupture of the MPFL at its patellar insertion (white arrow), with the classic pattern of bone edema at the lateral femoral condyle (asterisk) and subchondral fracture due to impaction in the inferomedial patella (curved arrow). Coronal PD fat sat view showing (B) a full-thickness chondral lesion in the load-bearing area of the lateral femoral condyle (clear arrow), a free osteochondral fragment in the suprapatellar recess (clear arrowhead), and significant joint effusion. The intercondylar notch radiograph (C) confirms the presence of an osteochondral fragment in the suprapatellar recess (triangle).



**Fig. 2** Axial PD fat sat (A) and T2-weighted (B) views showing complete MPFL injury at its femoral attachment (white arrow) with extensive bone edema at the lateral femoral condyle confirming lateral dislocation (asterisk).

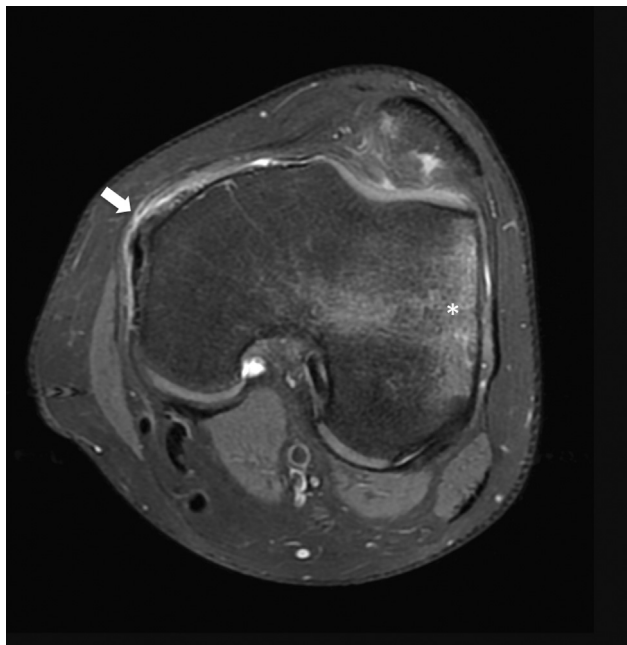


**Fig. 3** Axial PD fat sat (A) and T2-weighted (B) views showing a partial injury to the MPFL, with bony avulsion of its patellar attachment (white arrow), a subchondral impaction fracture of the inferomedial patella (curved arrow), and a bone edema at the lateral femoral condyle (asterisk).

lesion in both areas, and no case of total intrasubstance lesion. The 45 cases in which there was no evidence of fiber rupture presented peri- and intraligamentous edema of the MPFL, and its location was mainly in the patellar insertion (25 cases), followed by a multifocal lesion in 15 cases, with only 5 (11.1%) cases of lesion femoral.

In general, considering all levels of MPFL injury described, from edema to complete injury, these were located in the patellar insertion in 63.7% (58) of cases.

Osteochondral lesions were observed in 35 patients (38%) after the first episode of LPD. These were unifocal in all cases, except for 1 patient who presented it simultaneously with a patellar lesion and a lesion to the lateral femoral condyle. A



**Fig. 4** Axial PD fat sat view showing a partial lesion of the MPFL at its femoral insertion and bone edema due to impaction at the lateral femoral condyle (asterisk).

total of 22 (62.8%) osteochondral lesions were found in the patella, and 12 (34.2%), in the lateral femoral condyle. The mean maximum transverse diameter of the osteochondral lesions was of 11.3 mm (range: 2 mm to 23 mm).

## Discussion

The main findings of the present study are that the MPFL lesion was present in 50.5% (46) of the cases of LPD in children evaluated after a first episode, a figure lower than that reported in the literature.<sup>11,15</sup> In this pediatric cohort, the most frequent location was the patellar region, both for partial and total tears.

A frequent injury in children and adolescents, LPD has a high rate of recurrence, which may generate long-term

**Table 1** Summary of MPFL injuries in first-time lateral patellar dislocation in children

Lesion extent	Location	Number of cases (%)
Partial injury 36 cases (39.5%)	Patellar	26 (72.2%)
	Femoral	7 (19.4%)
	Multifocal	3 (8.3%)
Complete injury 10 cases (10.9%)	Patellar	7 (70%)
	Femoral	2 (20%)
	Multifocal	1 (10%)
No injury (edema) 45 cases (49.5%)	Patellar	25 (55.6%)
	Femoral	5 (11.1%)
	Multifocal	15 (33.3%)

disability. Several risk factors contribute to redislocation after the first episode, including trochlear dysplasia, patella alta, extensor apparatus misalignment, genu valgum, rotational deformities, and MPFL injuries, among others.

It is widely recognized in the literature that MPFL injury contributes to patellar instability, this being the main restrictor for lateral translation of the patella during the first 30° of knee flexion.<sup>5</sup> Therefore, an accurate assessment of the patterns of MPFL injuries after a first episode of LPD is key to a successful treatment approach.

Some studies<sup>11,15</sup> suggest that the patterns of MPFL injuries differs between children and adults; however, the findings are still contradictory due to the difficulty in comparing the various studies, which include mixed cohorts of children and adults, as well as new and chronic dislocations. In addition, not all studies detail whether edema was found as a sign of an acute episode on MRI scans.

The literature<sup>8,16,17</sup> traditionally mentions that MPFL injuries occur in the femoral region. However, the publication of case series with mixed or pediatric cohorts showed that MPFL patellar lesions were not as uncommon as previously thought.<sup>8,15</sup>

Using MRI Scans, Elias et al.<sup>7</sup> reported injury patterns of the MPFL in a mixed cohort of children and adults. They observed lesions in the patellar insertion in 76% of the cases, while in 49% of the cases in which the femoral origin of the ligament was observed, it was injured, highlighting that 48% presented multifocal lesions.

Balcarek et al.,<sup>6</sup> in a mixed cohort, found that multiple-site injuries to the MPFL were not as common, only being reported in 22% of the cases of LPD. These results are consistent with those of previous reports, and are similar to the findings of the present study.

Regarding the site of MPFL injury, Kepler et al.,<sup>15</sup> in an exclusively pediatric cohort of 43 patients, observed and reported a predominance of isolated injury in the patellar insertion (61%), finding only 12% of isolated injuries at the femoral insertion, and 12% of multifocal lesions.<sup>15</sup>

Confirming this hypothesis, Felus and Kowalczyk,<sup>14</sup> in a cohort of 50 pediatric patients who underwent surgery after a first-time LPD, reported a patellar MPFL lesion in 66% of the cases. After an analysis by age, the results showed a rate of 79% of lesions at this site in skeletally-immature patients versus 54% in skeletally-mature patients, reaffirming what has been evidenced in the present work.

The MPFL attachment to the medial border of the patella remains cartilaginous until the ages of 16 to 18 years, while the femoral attachment to the distal femur ossifies at around 13 to 15 years. The hypothesis is then raised that lesions at the border between cartilage and bone could explain the susceptibility of younger patients to suffer these lesions in the patellar region.<sup>14</sup>

Askenberger et al.,<sup>2</sup> in a cohort of patients under 14 years of age with acute LPD, reported lesions at the patellar attachment in isolation or as part of a multifocal lesion in 95% of the cases, while only 4% had isolated femoral injuries.<sup>2</sup>

Seeley et al.,<sup>1</sup> published one of the largest pediatric cohorts to date, reporting patterns of MPFL injury in 111 adolescents

after an acute episode. In line with the present study, they<sup>1</sup> showed that not all LPDs present with MPFL ruptures in this age group, finding injuries to this ligament in 78.4% of the cases (87/111), that is, a rate 27.9% higher than that of the present study. They<sup>1</sup> describe the location in the femoral insertion zone in isolation in 14%, and in the patellar insertion zone in 31% (34), while in 33% (37) of the cases there was evidence of a multifocal MPFL lesion.

However, there are also reports of an incidence of lesions in the patellar region in fewer than a third of patients.<sup>18,19</sup> As aforementioned, the results should be viewed with caution based on sample sizes, inclusion criteria, injury acuity, and age of the cohorts in question.

Osteochondral injuries are a common consequence of LPD that can lead to knee pain and long-term complications. Previous studies<sup>20,21</sup> have reported an incidence of these injuries after an acute episode ranging from 21% to 54%.

It has been suggested that the mechanism of injury is an impaction of the medial facet of the patella against the lateral femoral condyle.<sup>22</sup> In line with our findings, Kepler et al.,<sup>15</sup> in a pediatric cohort of 44 patients, reported an incidence of 23% of osteochondral lesions, with a mean maximum diameter of 12.5 mm.

Treating osteochondral injuries can be very challenging, so starting with an accurate diagnosis is crucial. The high incidence of these injuries clearly supports the use of MRI scans after the first episode of LPD.

The main limitation of the present study is its retrospective design; while its main strengths are the large number of patients included, which turned out to be one of the largest cohorts published to date dedicated exclusively to pediatric patients, and we were able to confirm the acute temporality of the lesion in all cases through MRI scans. For future studies, linking the analysis of the findings with skeletal maturity may help improve the recognition of the patterns of MPFL injuries.

## Conclusion

The MRI has been shown to be a valuable diagnostic tool for patellar instability in children and adolescents. In the present study, MPFL injuries were only present in half of the cases of LPD in children, with partial MPFL injury at the patellar insertion being the most common pattern in skeletally-immature patients during the first episode in our sample. More than a third of children with LPD have a concomitant osteochondral injury, mainly in the patella, so we consider that the use of MRI scans is essential for the accurate recognition of the injury pattern and its associated injuries in this age group.

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### Conflict of Interests

The authors have no conflict of interests to declare.

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