Acute lateral patellar dislocation in the pediatric population - common injury patterns on 3T MRI

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Authors: M. Akhlebinina, I. Melnikov, T. Karmanova, I. Blokhin, T. Akhadov; Moscow/RU
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Learning objectives

- To demonstrate characteristic aspects of patient positioning in acute patellar dislocation for damage evaluation using 3T MRI

- To describe main anatomical structures prone to injuries in pediatric acute patellar dislocation

- To highlight treatment options depending on the detected lesions and to provide clinical examples
Background

Acute lateral patellar dislocation accounts for about 2-3% of all knee injuries [1]. The prevalence of acute patellar dislocation is 6-77 per 100,000 population [4].

Patellar dislocation typically initially occurs with twisting knee movement during which the medial ligamentous stabilizers rupture and the patella hits the lateral femoral condyle [4].

In the long term, this can lead to chronic inflammation and degenerative joint disease manifested by joint instability and persistent pain [1,3,4]. Many authors reported a high redislocation rate of up to 15% [2,3,4]. Recurrent patellar dislocations usually occur in the individuals with variant anatomy of the patellar stabilizers [4]. Recurrent dislocations lead to the decreased motor activity [1,2,4].

Previously, traumatologists preferred conservative therapy of acute patellar dislocations with exception of osteochondral lesions and bone fragment dislocation. However, a high rate of negative outcomes, such as patellar remodeling and consequent joint instability, have necessitated a more detailed evaluation of knee joint structures including the configuration of patello-femoral joint and the state of patellar stabilizers [1].

MR imaging is the current primary diagnostic modality, replacing invasive diagnostic arthroscopy. MR imaging has been shown to be a highly sensitive cross-sectional imaging modality for detecting capsular, ligamentous, cartilaginous, and bone injuries associated with patellar dislocation [4]. CT is the best method of evaluating patello-femoral alignment, various risk factors for dislocation, and for osteochondral defect detection. It is also useful for measuring tibial tuberosity trochlear groove (TT-TG) distance, Insall-Salvati ratio and for evaluating trochlear dysplasia. The etiology of patellar instability is multifactorial [5,6,8].

A high prevalence of joint instability has increased the number of surgical interventions at the initial stage of treatment and reconstructions of the medial patellar stabilizers [1]. Surgical treatment has two goals: to repair damage caused by patellar dislocation and to correct those anomalies that are known to contribute to future dislocations [4].
Findings and procedure details

Since 2004, 2522 children with knee joint injuries have been hospitalized at the Clinical and Research Institute of Emergency Pediatric Surgery and Trauma. 1160 (46%) of them had acute lateral patellar dislocation (55% boys, 33% girls). The most common injury mechanism was internal rotation of a flexed knee with planted foot and valgus component.

Complaints and physical examination:
- soft tissue swelling
- patello-femoral pain syndrome
- pain on knee flexion
- patellar instability is evaluated via the moving patellar apprehension test.

In the overwhelming majority of cases, CT and MRI were performed within the first 24 hours after the injury. Philips Achieva (Holland) unit with magnetic field strength of 3T and Philips Brilliance CT 16-slice scanner were used. Comprehensive assessment of trauma mechanism, clinical signs and symptoms, CT and MRI data was carried out and correlated with arthroscopy.

In our experience, during CT field-of-view should be extended to cover both injured and uninjured knee.

MRI protocol and positioning:
1. A knee coil should be used.

2. Knee should be imaged in three orthogonal planes (axial, sagittal, and coronal). Two or more sequences should be obtained with fat saturation and at least two sequences without it.

3. Images are obtained with 3-mm slice thickness and 10% interslice gap.

4. Standard imaging sequences are axial proton density-weighted fat-suppressed, coronal T1-weighted or PD-weighted, coronal proton density-weighted or T2-weighted fat-suppressed, sagittal proton density-weighted and PD-weighted or T2-weighted fat-suppressed.
5. Knee should be flexed at about 30 degrees for the optimal joint index evaluation (Fig. 1 on page 19).

**Fig. 1**: Incorrect patient positioning with unbent knee. Knee should be flexed at about 30 degrees for the optimal joint index evaluation.

**References**: Radiology department, Clinical and Research Institute of Emergency Pediatric Surgery and Trauma - Moscow/RU

**Patellar instability risk factors**:

- patella alta (Fig. 2 on page 19)

- trochlear dysplasia (Fig. 3 on page 20, Fig. 4 on page 21, Fig. 5 on page 22)

- lateralized tibial tuberosity (increased tibial tuberosity-trochlear groove distance) (Fig. 6 on page 23, Fig. 7 on page 24)

- genu valgum [5].

Patella alta.

Patella alta (high riding patella) describes a situation where the position of the patella is considered high. It can be measured via Insall-Salvati ratio, i.e. patella tendon to patella length (Fig. 2 on page 19). The ratio can be measured on a lateral knee x-ray or sagittal MRI. Ideally, the knee should be flexed at 30 degrees. The normal Insall-Salvati ratio (TL/PL) is between 0.8 and 1.2.
• patella baja: <0.8
• patella alta: >1.2.

**Fig. 2**: Sagittal PD-weighted MRI. Insall-Salvati ratio measurement - BC/AB

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Trochlear dysplasia.

Trochlear dysplasia is one of the main factors contributing to chronic patellofemoral instability. It is seen in almost 85% patients with acute lateral patellar dislocation. This developmental anomaly may result in loss of lateral patellar tracking and in lateral dislocation of the patella at the initiation of flexion.
Trochlear dysplasia can be evaluated at MR imaging by determining lateral trochlear inclination (Fig. 3 on page 20), trochlear facet asymmetry (Fig. 4 on page 21), or trochlear depth (Fig. 5 on page 22) [4].

**Fig. 3:** Axial PD SPAIR MRI. Lateral trochlear inclination. A line is drawn along the subchondral bone of the lateral trochlear facet, and a second line is drawn along the posterior aspect of the femoral condyles. The angle between the two lines is the inclination angle. An inclination angle of less than 11° indicates trochlear dysplasia [4].

**References:** Radiology department, Clinical and Research Institute of Emergency Pediatric Surgery and Trauma - Moscow/RU
**Fig. 4**: Axial PD SPAIR MRI. Trochlear facet asymmetry. Asymmetry of the medial facet length (M) and the lateral facet length (L) is calculated as the ratio of the medial facet length divided by the lateral facet length expressed as a percentage (M/L × 100%). A trochlear facet ratio of less than 40% indicates dysplasia [4].

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Fig. 5: Axial PD SPAIR MRI. Trochlear depth. A line drawn parallel to the posterior aspect of the femoral condyles serves as a reference line (line D). The lines drawn perpendicular to the reference line indicate the largest anteroposterior diameters of the lateral (line A) and medial (line C) trochlear facets and the deepest point of the sulcus (line B). Trochlear depth is calculated as follows: \( (A + C/2) - B \). A trochlear depth of 3 mm or less is assumed to indicate dysplasia [4].

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Lateralized tibial tuberosity.

Patellar translation (TT-TG distance) is performed by overlapping or superimposing axial images of the femoral condyles and tibial tuberosity (Fig. 6 on page 23, Fig. 7 on page...
A distance of <15 mm is considered normal; 15-20 mm is considered borderline and a distance >20 mm is considered abnormal.

**Fig. 6:** Axial CT, MIP mode. Tibial tubercle to trochlear groove (TT-TG) distance measurement: overlapping of tibial tuberosity and trochlear groove slices. Normal distance.

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Fig. 7: Axial CT, MIP mode. Tibial tubercle to trochlear groove (TT-TG) distance measurement: overlapping of tibial tuberosity and trochlear groove slices. Abnormally increased distance.

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Typical diagnostic findings in lateral patellar dislocation (Fig. 8 on page 25):

- partial or full-thickness tear of the medial patello-femoral ligament (MPFL) (Fig. 11 on page 28, Fig. 13 on page 30, Fig. 15 on page 32, Fig. 17 on page 34, Fig. 18 on page 35)
Fig. 17: Axial PD-weighted MRI with fat saturation. Rupture of the medial retinaculum (purple arrow). Partial tear of the middle MPFL portion (yellow arrow). Partial MPFL tear at femoral attachment point (orange arrow). Haemarthrosis.

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- rupture of the medial retinaculum formed by anterior part of MPFL, medial patello-tibial ligament, medial patello-meniscal ligament, fascia and joint capsule (Fig. 9 on page 26, Fig. 11 on page 28, Fig. 15 on page 32, Fig. 17 on page 34)
Fig. 9: Coronal PD-weighted MRI with fat saturation. Rupture of the medial retinaculum (yellow arrow). Osteochondral fracture and bone contusion of the medial patellar facet (red arrow).

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- osteochondral and chondral fractures or bone contusion of medial patellar facet (Fig. 9 on page 26, Fig. 10 on page 27, Fig. 11 on page 28)

- osteochondral and chondral fractures or bone contusion of the lateral femoral condyle (Fig. 10 on page 27, Fig. 16 on page 33)
**Fig. 10**: Axial PD-weighted MRI with fat saturation. Bone contusion of the lateral femoral condyle and osteochondral fracture with bone contusion of medial patellar facet.

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- haemarthrosis (Fig. 17 on page 34, Fig. 18 on page 35) or lipohaemarthrosis (Fig. 14 on page 31) (hemarthrosis volume>50 mL indicates substantial injury of medial patellar stabilizers and/or osteochondral injury; fatty globules indicate osteochondral fracture [1])
Fig. 14: Axial PD-weighted MRI with fat saturation. Lipohaemarthrosis (three-layered effusion).

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- avulsion fracture with detached, nondisplaced fragment or with displaced (intra-articular) osseous or cartilaginous fragments (Fig. 12 on page 29, Fig. 16 on page 33).
Fig. 12: Coronal PD-weighted MRI. Intra-articular (detached) cartilaginous fragment (red arrow).

References: Radiology department, Clinical and Research Institute of Emergency Pediatric Surgery and Trauma - Moscow/RU
Fig. 16: Coronal PD-weighted MRI with fat saturation. Fracture of the lateral femoral condyle with non-displaced osteochondral fragment.

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Conservative treatment is possible in cases of:

- primary lateral patellar dislocation
- non-detached or non-displaced osteochondral fragment (stage II, III injury)
- partial tear of the MPFL at femoral attachment point or in the middle portion
- partial rupture of the medial retinaculum.

**Surgical intervention and reconstruction are necessary in cases of:**

- detached (intra-articular) osteochondral fragments (stage III-V injury) (Fig. 12 on page 29)

- full-thickness rupture of the medial retinaculum (Fig. 9 on page 26)

- full-thickness tear of the middle MPFL portion (Fig. 11 on page 28)

- one or more factors predisposing to the dislocation

- patellar redislocation.

The most common treatment options, in addition to MPFL reconstruction, are trochleoplasty, medialization of the tibial tuberosity and medial capsular plication.
Fig. 1: Incorrect patient positioning with unbent knee. Knee should be flexed at about 30 degrees for the optimal joint index evaluation.

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Fig. 6: Axial CT, MIP mode. Tibial tubercle to trochlear groove (TT-TG) distance measurement: overlapping of tibial tuberosity and trochlear groove slices. Normal distance.

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**Fig. 8:** Axial T2-weighted MRI. Regions of interest.

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Fig. 9: Coronal PD-weighted MRI with fat saturation. Rupture of the medial retinaculum (yellow arrow). Osteochondral fracture and bone contusion of the medial patellar facet (red arrow).

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Fig. 10: Axial PD-weighted MRI with fat saturation. Bone contusion of the lateral femoral condyle and osteochondral fracture with bone contusion of medial patellar facet.

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**Fig. 11**: Axial PD-weighted MRI with fat saturation. Full-thickness tear of the middle medial patello-femoral ligament portion (red arrow). Rupture of the medial retinaculum (yellow arrow). Osteochondral fracture and bone contusion of the medial patellar facet.

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Fig. 12: Coronal PD-weighted MRI. Intra-articular (detached) cartilaginous fragment (red arrow).

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**Fig. 13:** Axial PD-weighted MRI with fat saturation. Haemarthrosis. Full-thickness MPFL tear at its femoral attachment point.

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**Fig. 14:** Axial PD-weighted MRI with fat saturation. Lipohaemarthrosis (three-layered effusion).

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Fig. 15: Axial PD-weighted MRI with fat saturation. Partial tear of the middle MPFL portion. Rupture of the medial retinaculum.

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**Fig. 18:** Axial PD-weighted MRI with fat saturation. Partial MPFL tear at femoral attachment point (red arrow). Haemarthrosis.

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Conclusion

Diagnostics and treatment tactics in patients with lateral patellar dislocation depend on:

- assessment of MPFL (all three portions) and medial retinaculum for partial and full-thickness tears

- detection of loose intra-articular or non-displaced osteochondral or cartilaginous fragments

- detection of bone marrow edema or osteochondral fracture in inferomedial aspect of patella and in anterior part of lateral femoral condyle.

For the comprehensive assessment of patellar dislocation a radiologist should be able to identify typical injury patterns, should know standard methods for assessing risk factors for the patellar instability and be familiar with surgical options. Patients should be carefully divided into groups of surgical and conservative treatment. A more detailed evaluation of all described knee joint structures allows to define more accurate curative tactics.
Personal information

Address correspondence to M.Akhlebinina (e-mail: akhlebinina.m.i@gmail.com).
References


