Management of first-time patellar dislocation (FTPD): the ESSKA formal consensus

Introduction

Patellar instability is a common orthopedic problem. Patients with dislocated patellae are typically transferred acutely to the emergency room by ambulance, or they show up in the office weeks after the injury for the first time or everything in between. This demonstrates the wide variety of this injury, from dramatic and acute to less severe. The reason for this is the numerous different factors and circumstances leading to one final condition – patellar dislocation. Therefore, the same diagnosis might eventually have a completely different history and pathogenesis, which sometimes makes this field so complex.

Over the past 15 years, increasing knowledge has been gained in understanding the patellofemoral joint. The clear risk factors for dislocation were defined, and we know much more about the biomechanics and have developed new therapeutic strategies based on this new knowledge. Our treatment, especially surgical treatment, has therefore changed substantially in recent years, and it seems that we are making good progress with respect to clinical data.

There is still need for harmonizing definitions and terminology. It appears to be so clear to define a "first time patella dislocation" as the definition is obviously in the term itself. However, different authors use surprisingly different—sometimes diffuse—definitions of this event. This leads to incomparable data (e.g., incidence of FTPD) and some scientific uncertainties. The consensus group therefore suggests a simple definition of FTPD, which should be used for all further scientific projects around the topic:

"***FTPD is the first time event when the patella completely leaves the trochlear groove. The event has to be confirmed clinically and/or radiologically."***

This unification will help to obtain comparable data and eventually clarify some data variations in the literature. The real incidence of FTPD, for instance, is still unclear. The available data are extremely heterogeneous due to differences in the inclusion criteria. In summary, the incidence of FTPD is age related and is highest during growth spurt. It usually occurs in patients younger than 18 years of age eventually, with a tendency toward female patients. FTPDs in adults older than 25 years are rare. The reported overall incidence varies between 10-150/100,000 patient years and may be region specific, as the reported numbers have high deviations.

Despite all the scientific output in the field of patellofemoral instability, there are still many open questions that might – possibly – never be answered by clinical studies for various reasons (e.g., inhomogeneous patient cohorts, low patient numbers in some subetiologies). This is where a consensus project can provide valuable guidance and recommendations.

The strength of this method is to combine scientific evidence and expert opinions in the field and to have this peer reviewed conclusion with the highest level of agreement. This can be extremely useful as a guideline for everyone working in this field.

Of course there are region specific differences in health systems (availability of diagnostic modalities, limited capacities, waiting lists, …) or long time used therapeutic traditions that are used in certain European areas. A consensus cannot respect all these local aspects in full extent. It provides – based on a very structured process – an "ideal" model of a diagnostic or therapeutic approach that would be

desirable to be possible throughout Europe, but leaves enough leeway to respect region specific circumstances. A consensus should be used to influence local health politics to improve certain issues.

First-time patellar dislocation (FTPD) is the starting point of objective patellar instability. Either it stays a single event, or it is followed by recurrent dislocations or subluxations. Even ongoing symptoms such as patellofemoral pain or a limitation of the knee-related quality of life can be expected. The risk factors for FTPD are clearly understood. They do not differ from those of chronic cases. There are anatomical risk factors and others (see Table 1).

anatomical	**others**
Trochlea dysplasia	age
Patella alta	hyperlaxity
coronal and torsional (frontal) malalignment	Trauma intensity
lateral position of tibial tubercule	

But it´s not only the presence or absence of risk factors that influence our decision making. The patient´s medical history (e.g. intensity of trauma leading to FTPD, bilateral instability) must also be considered when planning a therapeutic strategy. Therefore, the etiology of FTPD is extremely important, and decision making must be individualized and must not be based exclusively on clinical or radiological measurements. When treating children, FTPD can also be the first sign of an undiagnosed syndrome (for example, Ehlers–Danlos syndrome).

Interestingly, there are more open questions about FTPD than about chronic cases. Despite the clear definition of FTPD, the clinical questions of whether to treat this disease surgically are still unsolved. The ESSKA committee for patella instability developed essential questions and statements on this topic in an attempt to combine the available literature and clinical experience.

Methodology:

The aim of the formal ESSKA consensus process is to assist clinicians in decision making for the management of patients after FTPD by combining scientific academic evidence and clinical expertise. Our goal is to propose recommendations rather than strict guidelines. ESSKA´s “formal consensus methodology” derived from the Delphi methodology was used. The core group comprised a steering group of 12 experts. This steering group was divided into a question group and a literature group, which worked independently. The question group proposed a series of relevant questions. The list was reviewed by the entire Steering Group, followed by a literature review for every single question performed by the literature group. Based upon these questions, the Group produced statements/recommendations that were reviewed by the entire steering group. For all these statements, 100% agreement within the steering group was achieved.

For each statement, the following grading system was used:

Grade A: high scientific level
Grade B: Scientific presumption
Grade C: low scientific level
Grade D: expert opinion

The literature summary was analysed according to the known classification of evidence levels:

Level I: Evidence from systematic reviews or meta-analyses of randomized controlled trials (RCTs). These are considered the highest-quality evidence because they involve rigorous study designs and large sample sizes.

Level II: Evidence from well-designed RCTs. Although not as comprehensive as systematic reviews, individual RCTs provide strong evidence when properly conducted.

Level III: Evidence from well-designed nonrandomized controlled trials. These studies lack randomization but are still carefully designed and can provide valuable insights.

Level IV: Evidence from well-designed case–control or cohort studies. These observational studies can contribute to our understanding of causation and associations.

Level V: Evidence from systematic reviews of descriptive and qualitative studies. Although not as strong as experimental studies, these reviews can provide important insights into complex healthcare issues.

Level VI: Evidence from single descriptive or qualitative studies. These studies provide limited but valuable information, especially when little other evidence exists.

Level VII: Evidence from expert opinion and consensus statements. This level represents the lowest level of evidence and is often used when no research-based evidence is available.

A rating group composed of an independent panel of 24 experienced clinicians was then asked to review the statements produced by the steering group. The rating phase consisted of two rounds, during which the panel evaluated and ranked each answer according to a discrete numerical scale (Likert scale from 1 to 9). Appropriateness and agreement was assessed. After the first round, the text was modified by the steering group, considering the rating group comments, and a second review by the rating group was then carried out. After this, a combined meeting of the steering and rating groups was organized to validate the draft and finalize the text.

The finalized text was then be circulated among the peer review group to assess geographic adaptability and acceptance among Europeans.

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Florian Dirisamer
Consensus Chair

Lars Blond
Consensus Co-Chair

Q1) Is trauma intensity leading to dislocation or the mechanism of dislocation important for further decision making?

Statement:
There is an inverse correlation between the intensity of trauma leading to FTPD and the underlying pathoanatomic risk factors, meaning that low trauma intensity usually indicates more severe underlying abnormalities. Therefore, the evaluation of trauma intensity provides relevant information in a patient´s workup and for clinical decision making.

Grade: C
Rating: median 9 (range 7-9)

Literature summary:

Most patellar dislocations occurred in patients who were self-reported athletes, with the most common primary sports being soccer, basketball, dancing, football, gymnastics, and baseball/softball[5]. Movement to flexion occurred in 84% of patients with primary patellar dislocations, and movement to extension occurred in 8% of patients[3].
Spontaneous patellar relocation is common in skeletally immature girls, and locked dislocation is common in skeletally mature men[3]. Low-risk and no-risk pivoting injuries were most common in women, whereas FTPD in men occurred mostly during high-risk pivoting activities[2]. This was accompanied by more pronounced trochlear dysplasia and an increased TT-TG distance in the female patient cohort[2]. Traumatic first-time dislocations resulting from a direct hit or fall occurred in only 3% of men and women, respectively[2].
A study of skeletally immature patients between 9 and 14 years of age with haemarthrosis after FTPD revealed that 96% had at least one and 79% had 2-4 pathoanatomic risk factors for patellar instability, and 74% had trochlear dysplasia (trochlear depth ≤ 3 mm), defined as Dejour type A or B. No severe trochlear dysplasia (type C or D) was found in this group[1]. Conversely, in minor trauma cases, only 14% of patients presented a normal trochlear configuration[4]. In addition, the high rate of recurrent dislocations (50%) and the low percentage of "normal knees" (5%) in this group – considering established thresholds of patellar instability risk factors – indicate that the more pathoanatomy is present, the less force is required to dislocate the patella laterally.

Level of Evidence: 3

References:

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Q2a) What are the relevant clinical signs in the acute phase or at a later visit after FTPD?

Statement:
In the acute phase, examination of the knee might be difficult due to swelling, hemarthrosis and general or localized knee pain. However, the examination should aim to identify whether the patella was dislocated or to detect other types of injury. Patients with suspected hemarthrosis need further MRI investigation as soon as possible and may indicate punction for pain relief. When the acute phase has resolved, a testing protocol consisting of the J-sign, visual assessment of axial and torsional alignment, range of motion, apprehension test/reversed dynamic patellar apprehension test and patellar glide test is recommended.

Grade: D
Rating: median 9 (range 5-9)

Q2b) What are the relevant factors in patient history after FTPD?

Statement:
In addition to the clinical investigation, patient age, family history, bilateral symptoms of instability, and injury mechanism should be evaluated.

Grade: B
Rating: median 9 (range 7-9)

Literature summary:

Clinical assessment of FTPD in the acute phase might be challenging because of the pain and swelling that has been elicited[6, 9]. The primary purpose of the first-time assessment is to identify whether the patella was dislocated or to detect other types of injury[5].

A severe joint condition is present in approximately 70% of patients who present with acute, posttraumatic knee hemarthrosis. The incidence of FTPD in children younger than 14 years of age is 3.5-fold greater than that in children with ACL injury (41% vs 12% of all knee injuries with hemarthrosis)[1], and patellar dislocation is the second most common cause (after ACL injury) of hemarthrosis in the general population[3, 10]. In the majority of FTPD patients, the patella reduces spontaneously, and only 20% of patellar dislocations require reduction in the emergency unit[2].

In FTPD patients with persistent dislocation, the clinical assessment and diagnosis are often clear. The patient is in acute pain, the knee is deformed by the laterally dislocated patella, and the knee is typically fixed in a flexed position. Knee hematoma might already be present and is frequently severe and expanding over time[2]. Dimple signs on the medial aspect of the knee might be observed if the patient presents shortly after the incidence of dislocation with no reduction[8]. Radiographs confirm the diagnosis, as the knee might be difficult to examine in more detail. However, in 80% of FTPD patients, spontaneous reduction occurs before the patient is seen by a medical professional[2].

Clinical assessment should focus on the following factors[2, 7]:

1. Acute signs:

- Haemarthrosis (severity and location)
- haematoma,
- pain or painful MPFL course palpation

- loss of tendon or muscle continuity at the patellar insertion of the vastus medialis and MPFL

2. range of motion (ROM):

- extension lag and/or inability to adequately tension the quadriceps muscle
- painful flexion contracture

3. Signs of patellar instability:

- positive or painful apprehension test
- patellar hypermobility
- patella that is easily redislocated
- contralateral patellar hypermobility/instability

4. Predisposing factors:

- Coronal and rotational malalignment
- hyperextension or hyperlaxity
- Family history of patellar dislocations

5. Exclusion of the other conditions (for example):

- ACL, MCL, meniscal injury
- fractures

Arthrocentesis might be indicated to relieve pain and facilitate clinical and radiological examination. Fatty lobules in the joint fluid may indicate osteochondral fracture or bone impaction[4, 8, 10].

It is recommended that the clinical examination be repeated as soon as the acute phase has resolved after the initial examination[8, 10]. The recommended testing protocol for the nonacute phase is further discussed in Chapters 6 and 7.

Level of evidence: 2

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Q3) What is the patellofemoral clinical testing protocol after FTPD to be performed in every case?

Statement:
Examination of the knee after FTPD might be limited in the inflammatory acute phase due to swelling, pain, and patient anxiety. If so, it should be repeated as soon as the acute phase has resolved (from days to weeks) to confirm the initial diagnosis and to assess predisposing factors, including the contralateral knee. The examination should include standing, supine and prone position assessments of coronal and axial deformity, knee joint range of motion, J-sign, patella gliding and apprehension/reversed dynamic patella apprehension. This does not exclude the need for systematic examination of other knee structures.

Grade: D
Rating: median 9 (range 7-9)

Literature summary:

Designated tests implicate or rule out pathologies, guiding clinicians to correct diagnosis and treatment[13, 14, 22]. Acute FTPD might present as a dislocated patella, as a spontaneously relocated patella after dislocation or as occult dislocation/subluxation where the patient reports a “pop out” feeling only. Twenty percent of patellar dislocations require reduction in the emergency unit[6]. It has been estimated that 50–75% of cases are misdiagnosed or overlooked at the time of initial clinical evaluation[7].

Clinical assessment of FTPD in the acute phase is challenging because of the resulting pain and swelling[12, 17]. To assist in this situation, the contralateral knee can be examined to provide information regarding what may be ‘normal’ for this patient[23]. Clinical conclusions should be drawn from the main tests, which should be performed in an average examination time of 3-5 minutes. It is recommended that the clinical examination be repeated approximately one week after the initial evaluation[15].

On the one hand, current research focuses on imaging-based evaluation of thresholds and indices describing joint abnormalities; however, values are often observer dependent and influenced by nuances of the imaging modalities. In addition, this approach includes the risk of neglecting the clinical aspect of patellar dislocation[9, 18, 26]**.** On the other hand, many physicians are not adequately trained in the evaluation of many musculoskeletal problems [1, 4, 9], and the value of a detailed physical examination has been questioned[2, 3, 17, 20]. However, recent studies have demonstrated the importance of clinical findings indicating patients’ disease-specific quality of life, the success of MPFL reconstruction, and determining treatment strategies for lateral patellar instability[16, 25, 27].

Clinical tests represent the basic step in the process of determining a treatment strategy to assess and approximate the severity of risk factors relevant for lateral patellar instability[5, 26]. Even today, new tests have been developed and are gaining popularity due to their clinical relevance—the reverse dynamic patellar apprehension test may serve as an example[26]. Others have become outdated and disappear[20]; some still need to gain popularity[24].

Recommended testing includes but is not limited to the following (not ranked):

1. Standing position: evaluate for knee valgus and internal rotation with inwardly pointed knees. Patients should be able to actively correct the inwardly pointed patellae position. If the patient can correct the condition, it indicates a weakness of the hip external rotators. Otherwise, an increased torsional deformity may be present. In addition, flatfoot can cause excessive inwards twisting of the tibia, leading to an inwardly pointed patella.
2. Passive and active knee range of motion in supine position: evaluate for high patellofemoral instability (PFI) with spontaneous dislocation in flexion, which is a sign of severe trochlear dysplasia, hypoplasia of the lateral femur, extensive rupture of the medial capsule, the MPFL, the MPTFL and M. vastus medialis. PFI near extension is typically associated with a positive J-sign, which is caused by a lateral shift of the patella during active knee extension when the patella has no buttress from the lateral trochlea and no restraint from the MPFL. Thus, a short trochlea, trochlear dysplasia, and patella alta may be the reasons for a positive J-sign. Increased valgus or torsional deformities or a lateralized tibial tubercle (more than 1 cm lateral to the centred patella in the trochlear groove in 90° flexion) may also be present and can be observed in extension and flexion. Flexion-valgus should be noted as a sign of posterolateral femoral hypoplasia and/or increased femoral torsional deformity.
3. Patellar glide test and apprehension test/reversed dynamic apprehension test: Gliding of the patella should be between 1 and 2 medial to lateral and without pain or fear of dislocation. The apprehension test is a continuation of the patella glide test and is continued until the patient feels fear of dislocating the patella or the patella dislocates or the patient is contracting the quadriceps to relocate or prevent patellar dislocation. This kind of reaction is considered an objective sign of the PFI.
4. With the patient in the prone position, the knees are flexed to 90°, and the feet are turned outwards to test for increased torsional deformity of the femur. An internal rotation of the lower leg/hip of more than 70° indicates increased femoral antetorsion and should be further investigated with torsional MRI/CT[21]. In these cases, imaging should include tibial torsion assessment as well.

The sensitivity/specificity and reliability/validity of diagnostic tests remain unclear[8, 19]. Some authors indicate insufficient evidence to support tests in clinical practice[20]. It has even been suggested that standard tests (J-sign, Q-angle, and apprehension test) are not reliable for communication between health care practitioners or for evaluations in clinical research[11].

Despite being of uncertain scientific value, the authors strongly recommend clinical tests for FTPD assessment. Clinical evaluation still represents the first-line approach for locating and identifying clinical problems, assuring patient safety and designing further directed imaging diagnostics.

Follow-up examination
In the authors' opinion, clinical testing is also extremely important during follow-up assessments. Patient satisfaction and clinical outcomes are essential[10, 16].

Level of evidence: 4

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Q4) Can we indicate nonsurgical treatment just by clinical examination?

Statement:
In patients with FTPD, it is strongly recommended not only to rely on clinical examination but also to perform imaging evaluation to diagnose osteochondral fractures, evaluate predisposing factors and skeletal maturity and thereby estimate the risk of persistent instability. Further decision making on either surgical or nonsurgical treatment should be based on the assembled information of the patient's medical history, clinical examination and imaging findings.

Grade: C
Rating: median 9 (range 5-9)

Literature summary:

Surgical treatment is principally based on abnormal anatomy requiring surgical correction. Several factors of patellofemoral instability (PFI) have been defined in the literature, and severe pathoanatomy may lead to PFI with moderate or even normal pivoting movements, such as turning on the extended knee.
In all patients with suspected FTPD, conventional radiographs and MRI are needed to confirm or exclude pathological findings beyond clinical examination. Thus, clinical examination alone is rarely able to indicate nonsurgical treatment. Only in rare cases can nonsurgical treatment be indicated if adequate trauma (directly against the medial patella) causes patellar dislocation and the patient has no apprehension on clinical examination, no effusion, and no obvious malalignment (straight leg, no torsional deformity). However, radiographs and MRI are still needed to rule out osteochondral fractures.
FTPD is usually associated with intraarticular effusion, tenderness along the medial patellar facet and medial retinaculum, unclear apprehension and often associated with abnormal findings such as a high riding patella, valgus knee, increased femur antetorsion, lateral tilted patella, and signs of trochlear dysplasia or a lateralized tibial tubercle. In addition, early examination may be limited because of pain and patients' fear of patellar manipulation[1, 4, 5, 9, 10].

It has been estimated and reported that osteochondral fractures are found in 25 to 75% of FTPDs. Higher numbers are reported in younger patients, which is a predisposing factor for future OA development[6, 8]. Moreover, it has been estimated that 50–75% of all FTPD patients are misdiagnosed at the time of initial clinical evaluation.

The greater the risk of experiencing a second patellar dislocation is, the more risk factors are present[2, 7], and clinical assessment alone is prone to underestimate the presence and severity of a given

pathoanatomy. Thus, basing the treatment decision only on clinical evaluation would counteract current recommendations of individual risk stratification models in FTPD[3].

Level of evidence: 3

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Q5a) Do we need to obtain radiographs and/or MR images for every patient with FTPD?

Q5b) Is the final diagnosis of FTPD a meaningful combination of clinical testing, imaging and patient history?

Statement:
After FTPD, prompt X-ray (ap, lateral and axial) and MRI or MRI alone of the knee is considered mandatory to rule out osteochondral fractures and/or bony abnormalities. X-rays are mandatory in the acute phase only in cases where you do not have access to immediate MRI. However, an exception might be an asymptomatic patient seen relatively late after the incident who presents with a normal clinical knee examination. The final diagnosis of FTPD and further decision making are always meaningful combinations of complete patient workups and should not rely only on images.

Grade: C
Rating: median 9 (range 6-9)

Literature summary:

As noted previously, clinical examination is not accurate enough for the assessment of three important issues associated with FTPD. First, it is unlikely to exclude the presence of traumatic cartilage damage/osteochondral fractures and loose bodies. Second, clinical assessment alone has limited value in the assessment of (patho)anatomic risk factors that might be present—to a variable degree—in every patient. Third, we aimed to confirm the diagnosis, especially in children with hemarthrosis after

knee trauma. In a study of occult intraarticular knee injuries in children, 27% of the FTPDs could not be discerned from physical examinations. These patients had nonspecific hemarthrosis with no bony lesions on the radiographs; the diagnosis of lateral patellar dislocation was confirmed using MRI[1]. Basing the treatment decision only on clinical evaluation would counteract current recommendations of individual risk stratification models for clinical decision making. Thus, anteroposterior, lateral, and patellar axial radiographs and magnetic resonance imaging (MRI) are considered obligatory for the evaluation and assessment of FTPD[2–10]. The Table (from [9]) lists additional indications for MRI after suspected patellar dislocation.

Indications for MRI after suspected patella dislocation
Haemarthrosis
Concern for osteochondral injury
Locked knee
Alternative injury suspected
Diagnosis uncertain (eg. ACL Tear vs. Patella dislocation)
Difficult patient assessment (eg. morbidly obese patient)
Symtoms continue after conservative treatment

Follow-up examination

In the authors' opinion, imaging is also important for follow-up assessment. It is mandatory to check the hardware position and surgically restored anatomy, as this influences the clinical outcome.

Level of evidence: 4

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Q6) What is the minimum imaging protocol after FTPD to be performed in every case?

Statement:
In the acute phase after FTPD, plain radiographs (ap, lateral and axial) and MRI, or MRI alone (if accessible immediately), are the required minimum imaging protocol, to be performed as soon as available. In the chronic phase, precise plain X-rays (ap, true lateral in 30° flexion and axial) and MRI, or MRI alone, should be performed. However, an exception might be an asymptomatic patient seen relatively late after the incident who presents with a normal clinical knee examination.

Grade: D
Rating: median 9 (range 5-9)

Literature summary:

In FTPD patients, radiological evaluation follows clinical examination. Most of the patients are admitted to the emergency department for imaging and are primarily dedicated to excluding fractures and joint dislocations. In most institutions, the basic protocol includes plain radiographs (ap/lateral and axial view)[7, 9, 11]. Although radiographs may reveal gross pathology/injury in the acutely injured knee joint, they are usually of less value in terms of the diagnosis and presentation of risk factors due to the common inexact imaging setting, soft tissue radiolucency and potential masking of torsional deformities[3, 9].

CT and MRI are valuable and implemented techniques that are often available in emergency units[8, 13]. Both may direct the diagnosis in clinically unsuspected patients. In addition, concomitant injuries that ultimately confirm or change the diagnosis and treatment plan are expected to be identified[1, 4, 5, 12, 14]. Specifically, MRI is helpful for locating radiolucent loose bodies, diagnosing chondral and osteochondral injuries, and displaying MPFL injury patterns in FTPD patients[2, 4, 10]. Finally, MRI is considered a validated method for the diagnosis and characterization of patellar instability[6].

Level of evidence: 4

References:

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Q7) Which radiologic parameters have to be assessed?

Statement:
The radiological parameters to be measured, depending on clinical presentation, include patellar height, patellotrochlear overlap, trochlear geometry, and axial alignment (tibial tubercle position and knee rotation). Depending on clinical findings on coronal and rotational alignment, additional imaging evaluations may be necessary. There is currently no consensus on clear cut-off values for these parameters.

Grade: D
Rating: median 9 (range 7-9)

Literature summary:

Radiographic techniques for evaluating the PFI include plain radiographs, magnetic resonance imaging (MRI), multidetector computed tomography (MDCT), dynamic MRI, and 4-dimensional computed tomography (4DCT)[2, 3, 5, 6]. Moreover, ultrasound examination is advocated for being useful in the assessment of patellar position and loose body identification[1].

Each individual technique offers the possibility to measure multiple radiological parameters, and the number of available parameters is overwhelming. Over 106 parameters/indices have been described, including 39 for patellar alignment, 38 for trochlear morphology, 11 for patellar height, 10 for soft tissue description, and 4 each for patellar morphology and patellar inclination. A high number of different parameters clearly indicates the complexity of the PFI but also indicates the ambiguity of which parameters have the greatest relevance for clinical assessment and decision making. There is almost no consensus on mandatory measurements[3, 7].

Among the committee members, there was strong agreement that the Caton–Deschamps index, trochlear dysplasia and trochlear “bump” are the most important parameters to be assessed on plain radiographs. The axial view was considered most important for displaying osteochondral fractures. Tunnel view and stress axial views were considered not useful. There was also strong agreement that the tibial tuberosity–trochlear groove (TT–TG) distance (90%), lateral trochlear inclination angle (80%), tibial tuberosity–posterior cruciate ligament (TT–PCL) distance (70%), Biedert–Albrecht index (70%), Caton–Deschamps index (70%), and trochlear dysplasia (60%) are the most important MRI parameters to be assessed. The patellar tendon length had no value. None of the voting members had experience with instrumental testing in cases of FTPD[4].

The authors strongly agreed that the assessment of patellar height, patellotrochlear overlap, trochlear configuration, sagittal and axial alignment (tibial tubercule position, knee rotation) is the minimum required protocol for every patient. Depending on clinical findings (coronal and rotational alignment), additional imaging evaluations may be necessary.

Level of evidence: 4

References:

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Q8) When do we need more imaging than standard radiographs (ap, lateral, axial) and MRI, and which measurements should then be performed?

Statement:
When clinical examination gives rise to suspicion of valgus deformity, well-executed long-standing X-rays are recommended. The signs of squinting patella and/or if examination in the prone position shows a difference of more than 30 degrees between internal and external rotation of the hip or clinical suspicion of increased tibial external torsion, further radiological assessment by torsional CT or MRI investigation is recommended to measure femoral antetorsion, knee rotation and tibial external torsion.

Grade: C
Rating: median 9 (range 5-9)

Literature summary:

Torsional deformity and coronal axis deviation can contribute to patellar instability[7, 15, 20]. In addition, it has been reported that increased femoral antetorsion influences the clinical results of surgical treatment for patellar instability[6, 21, 30], and valgus malalignment is considered to be a risk factor for FTPD, considerably influencing lateral patellar shift and tilt[1, 4, 17, 28].

The clinical examination should include evaluation of the patient in standing, supine, and prone position to evaluate for possible knee valgus or/and torsional malalignment (please see question no. 6)[3, 25, 27]. Conventional radiographs and standard MRI scans of the knee are the recommended minimum diagnostic protocols (question no. 9); however, neither are capable of full coronal or axial deformity assessment[8, 9, 15, 18–20].

Clinical findings indicative of genu valgum and increased femoral and/or tibial torsion include the following:

- tibiofemoral angle in stance with an intermalleolar distance >8 cm.
- appearance of a squinting patella or inwardly pointing knee in standing or supine position.
- A difference of more than 30 degrees between internal and external rotation of the hip in the prone position.
- > 70 degrees of internal hip rotation in the prone position[25].
- increase in tibial torsion in the prone position, as suggested by Stuberg[27].

These findings of clinical examination indicate further radiological assessment, including a standing long-leg axis radiograph and torsional CT or MRI investigation[5, 19, 23, 26].

Long-leg axis radiographs are used to diagnose and locate the source of the deviation in the coronal axis. An essential quality feature when acquiring a long-leg radiograph is centring of the patella between the femoral condyles and strict extension of the knee joint, which is usually associated with an outwards rotation of the feet of 8–10°[15, 20]. Alternatively, the tibiofibular 1/3 overlap radiograph acquisition technique can be applied if rotational deviations are expected (lateralized patella)[16]. Analysis of the geometry of the coronal leg should include the mechanical femorotibial angle (mFTA), mechanical lateral distal femoral angle (mLDFA), anatomical lateral distal femur angle (aLDFA), and mechanical medial proximal tibial angle (mMPTA), which are suggested to also be measured in FTPD patients[21]. A long leg axis ≥ 5° valgus in the presence of PF instability may influence surgical treatment[7].

For the assessment of torsional (mal)alignment, three parameters should be measured: femoral antetorsion, tibial torsion, and knee rotation (knee version)[5, 12, 23]. An internal torsion of -24.1° (± 17.4°) was described in the literature as the standard value for femoral torsion, and an external torsion of 34.9° (± 15.9°) was described for the tibia[26]. It is important to note that normative values strongly depend on the measurement technique used[13]. The average standard knee angle in a healthy population is 1.3°± 3.9° (range, -8.7° to 11.7°)[10]. An increase in femur/tibia torsion >10° of the normative value with corresponding clinical symptoms is considered an indication for surgery[26, 30]. However, the presence of increased torsion alone does not confirm patellar instability[2]. The cut-off value of the knee version angle (tibiofemoral rotation angle) for predicting MPFL graft failure in patients with recurrent patellar instability was 12°[31].

Previous investigations revealed associations between trochlear dysplasia and femur antetorsion and between knee version and the TT-TG distance[2, 11, 14, 21]. It might be argued, therefore, that in patients with severe trochlear dysplasia or an increased knee version angle on standard knee MRI, torsional profile assessment should follow, independent of clinical examination[11, 21]. Additionally, it should be considered that there is only a weak relationship between measures of femur antetorsion and dynamic hip rotation[22].
Conventional MRI reflects a static condition with no information about patellofemoral kinematics during active knee flexion-extension movement. Kinematic magnetic resonance imaging (MRI) has been introduced as a new diagnostic tool capable of revealing dynamic patellar movement[6, 24, 29]. However, dynamic MRI investigations are currently of greater scientific interest and have not yet been widely implemented in clinical practice.

<u>Conclusion:</u>
Radiographs and standard MRI scans should be supplemented by further imaging if the clinical examination and/or any of the standard radiographs or MRI measurements suggest severe rotational malalignment or coronal axis deviation.

Complementary investigations include the following:

- CT/MRI rotational profile
- Standing long-leg axis radiograph

Further optional examinations include the following:
- Gait analysis
- Kinematic MRI

Level of evidence: 3

References:

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Q9) When and how should a chondral or osteochondral fracture be diagnosed?

Statement:
The incidence of chondral or osteochondral fractures is high, especially in pediatric patients. Hemarthrosis/Lipohemarthrosis should serve as a warning sign. As chondral lesions in the patellofemoral articular area are important prognostic factors, imaging should start immediately with plain radiographs (ap, lateral, axial) and an MRI or an MRI alone as soon as possible to detect all these chondral and osteochondral lesions and to assess repairability.

Grade: C
Rating: median 9 (range 8-9)

Literature summary:

The exact incidence of an associated chondral or osteochondral fracture (OCF) is still unknown[4, 11] but might be higher and much more common than previously expected. The reported rates range from 25 to 75% and are more frequent in pediatric and adolescent age groups than in adults[9, 12].

Lateral patellar dislocation is the most common traumatic cause of osteochondral injury in pediatric patients. According to the biomechanics of the injury, the lateral edge of the lateral trochlear facet hits the vertical ridge and medial facet of the patella during dislocation or as the patella reduces into the groove. Thus, most injured areas are located at the medial patellar facet, at the lateral femoral condyle or both[3, 8, 11].

Injuries can vary from simple cracks or fissures to full-thickness chondral or osteochondral defects[9]. Osteochondral injury involves both the underlying bone and the articular cartilage and is traditionally considered to have greater healing potential due to the presence of subchondral bone. In contrast, chondral-only injuries are less common, are reported mainly in pediatric and adolescent patients, are more difficult to diagnose, and have lower healing potential. However, studies have shown that many of these allegedly chondral-only fragments contain minimal bone (<5 mm) attached to the undersurface[6].

The delay in diagnosis and treatment may limit the healing capacity of OCFs[4] and predispose patients to an increased risk of further damage and early posttraumatic arthritis, especially when involving the weight-bearing area[3, 9, 12]. For all these reasons, timely diagnosis of this injury is fundamental in FTPD patients.

A detailed medical history and a thorough physical examination are critical for determining the pattern of suspected injury[1, 13]. However, the correct diagnosis is often difficult in an urgent care setting, especially for pediatric patients, due to a lack of collaboration and an inability to accurately describe the symptoms and mechanism of injury[1, 13]. Hemarthrosis should serve as a warning sign of potentially severe intraarticular knee joint injury[1, 2, 12, 13]. Abbasi et al. reported that hemarthrosis was present in 31% of patients with patellar dislocation[1]. Wessel et al. reported that in patients who presented with hemarthrosis, 17.9% had patellar dislocation[13]. In a study of occult intraarticular knee injuries in children, Askenberger et al. showed that 27% of FTPDs could not be discerned via physical examinations. Patients had nonspecific hemarthrosis with no bony lesions on the radiographs; the diagnosis of lateral patellar dislocation was confirmed by MRI[2].

Imaging should start immediately with plain radiographs. Whenever possible, three views of the knee joint are recommended: anterior-posterior (AP), lateral, and patellar axial views. The ability of radiography to diagnose osteochondral lesions depends on the amount of subchondral bone. Radiographic findings in smaller bone fragments may be subtle and are often difficult to detect[1, 2, 4]. It has been reported that osteochondral fractures are overlooked in 30% to 44% of initial radiographs[11]. Therefore, the absence of abnormal findings on radiographs does not exclude chondral or osteochondral injury.

In the presence of traumatic knee effusion, it is recommended that patients, especially pediatric and adolescent patients, undergo advanced imaging evaluation as soon as possible, preferably within 2 weeks after the injury[2, 4]. MRI is increasingly considered the diagnostic tool of choice and is reliable and essential for investigating acute knee hemarthrosis, replacing diagnostic arthroscopy[2, 7, 14]. It is superior to other imaging methods for the diagnosis of chondral-only and osteochondral fragments. This allows a better characterization of the size, location, and quality of the lesion and the assessment of skeletal maturity when dealing with skeletally immature patients. MRI has 86% sensitivity and 97% specificity in identifying hyaline cartilage lesions in the knee[3]. According to Disler et al., several sequences are more effective in diagnosing and characterizing cartilage damage, allowing the diagnosis of approximately 44% of OCFs that were missed in plain radiographs[5]. However, it is important to consider that according to Pedersen et al., MRI overestimates the size of OCFs[10].
In certain conditions, computed tomography (CT) should also be considered a diagnostic tool. In the emergency setting, especially when radiographs suggest the presence of osteochondral fractures and when MRI scans are unavailable in the short term, CT remains a valuable imaging examination tool.

According to Wu et al., there was no significant difference in diagnostic accuracy between CT and MRI for intra-articular osteochondral fractures[15]. However, CT does not have the accuracy of MRI to detect chondral or other intra-articular soft tissue injuries (e.g. anterior cruciate ligament and meniscal injuries). It should be noted that the incidence of other lesions diagnosed by MRI, beyond those referred to the patellofemoral joint, is low. In this context, the incidence of meniscal lesions ranges from 2.8% to 21%[10, 15].

In conclusion, a high incidence of primary cartilage damage is expected after FTPD. MRI is the recommended examination after patellar dislocation and in cases of unclear injury associated with knee joint hemarthrosis. MRI is characterized by the highest accuracy in identifying chondral and osteochondral lesions, visualizing injury patterns and diagnosing or excluding other possible intraarticular knee joint injuries. In addition, it allows for evaluating possible bony pathoanatomy associated with lateral patellar instability.

Level of Evidence: 4

References:

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Q10) Is nonoperative treatment the gold standard for treating FTPD in skeletally mature patients?

Statement:
In skeletally mature patients, conservative treatment was the standard and most common treatment for FTPD in the past. Today, with respect to recent literature, there is a need to assess predisposing factors and the risk of ongoing symptoms and recurrence to make the final decision. Treatment should also be tailored to patient characteristics and demands. Therefore, the consensus group suggests conservative treatment only in patients with low recurrence risk (see also question 14) and without chondral or osteochondral lesions.

Grade: C
Rating: median 9 (range 5-9)

Literature summary:

Nonoperative management is often considered the first-line treatment for patellar instability despite the high rate of redislocation, which increases with follow-up (71% at 14 years)[11]. This traditional approach to conservative management of FTPD involves following old concepts and treating all types of instability equally. More recent evidence suggests individualized treatment based on predisposing factors and stratifying risk favours surgery[5, 7].

A systematic review of four meta-analyses with 1984 patients (997 surgical and 987 conservative treatment) reported a redislocation rate of 24% in the surgical group and 35% in the conservative group[6]. A meta-analysis by Fu et al[7] including nine studies and 492 patients reported a lower redislocation rate and higher Kujala score with surgical treatment at short-term follow-up, especially when considering surgeries performed within the last 10 years. Furthermore, a recent meta-analysis revealed that surgery provided a lower redislocation rate than nonsurgical treatment for FTPD for up to six years, as well as reduced symptoms and improved functional results[5]. Similar clinical results between the two groups were reported beyond six years, and a high risk of bias was found in most of the RCTs reviewed. The Cochrane review revealed a lower risk of dislocation with surgical treatment at 2-5 years and 6-9 years of follow-up[15]. Kujala scores also favoured the surgical group at the 2-5 year follow-up.
Table 1 reviews RCTs from 1997–2022 with 20–125 patients and 2–7 years of follow-up[1–4, 8, 10–14]. In six RCTs, the surgical procedure was repair, and MPFL reconstruction was performed in one study. The outcomes included the recurrence rate and a range of functional scores, with the Kujala score being the most widely used. In the repair studies, surgery was found to be superior in three patients, with no differences found in the other three patients. Only the MPFL reconstruction study revealed that surgical treatment was superior in terms of all parameters[2].

Limitations of the published literature include poor methodological quality, heterogeneity in patients studied, follow-up time, inclusion and exclusion criteria, surgical procedures and different scoring systems lacking sensitivity for patellofemoral populations[5, 9, 16]. The reliance on redislocation rates as the main outcome in most studies underlines the advantage of a more aggressive approach to restoring anatomy and improving patellar stabilization[5]. It is therefore not surprising in redislocation terms that surgery is supported. However, functional outcomes also suggest support for surgical intervention. The most commonly used PROM is the Kujala score, which does not capture disability following dislocation thoroughly[5, 16]. The activity level, symptoms of subjective instability, and quality of life have also been poorly reported[9].

Recent evidence supports a reduced redislocation rate and improved patient-reported outcomes when surgical treatment is used for skeletally mature patients with FTPD (3). Individualized surgery

that considers patient age and predisposing factors may be the future gold standard for treating FTPD, but well-designed, comparative studies assessing adverse events and returning to sports are needed.

Author	Year	Surgical Procedure	Outcome	N	F-up	Findings
Nikku	1997	MPFL repair	Recurrence rate, Hughston, Tegner and Lysholm	125	2 y	No diference
Christiansen	2008	MPFL repair	Recurrence rate, Kujala, KOOS	80	2 y	No diference
Camanho	2009	MPFL repair	Recurrence rate, Kujala	33	3 y	Surgery superior all parameters
Sillanpää	2009	MPFL repair or Roux-Goldhwait	Recurrence rate, Kujala, return to sports	40	7 y	Surgery superior in recurrence rate, rest no diference
Bitar	2012	MPFL reconstruction	Recurrence rate, Kujala	41	3.6y	Surgery superior all parameters
Petri	2013	MPFL repair	Recurrence rate, Kujala, patient satisfaction	20	2 y	No diference
Ji	2016	MPFL repair	Recurrence rate, Kujala, Subjective questionaire and radiological patellar tilt and shift	62	3.5 y	Better Kujala score and patelar tilt, rest no diferences

Table 1: Randomized control trials comparing operative and conservative treatments for patellar dislocation.

Level of Evidence: 2

References:

1. Askenberger M, Bengtsson Moström E, Ekström W, Arendt EA, Hellsten A, Mikkelsen C, Janarv P-M (2018) Operative Repair of Medial Patellofemoral Ligament Injury Versus Knee Brace in Children With an Acute First-Time Traumatic Patellar Dislocation: A Randomized Controlled Trial. Am J Sports Med 46(10):2328–2340
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Q10) Is nonoperative treatment the gold standard for treating FTPD in skeletally mature patients?

Statement:
In skeletally mature patients, conservative treatment was the standard and most common treatment for FTPD in the past. Today, with respect to recent literature, there is a need to assess predisposing factors and the risk of ongoing symptoms and recurrence to make the final decision. Treatment should also be tailored to patient characteristics and demands. Therefore, the consensus group suggests conservative treatment only in patients with low recurrence risk (see also question 14) and without chondral or osteochondral lesions.

Grade: C
Rating: median 9 (range 5-9)

Literature summary:

Nonoperative management is often considered the first-line treatment for patellar instability despite the high rate of redislocation, which increases with follow-up (71% at 14 years)[11]. This traditional approach to conservative management of FTPD involves following old concepts and treating all types of instability equally. More recent evidence suggests individualized treatment based on predisposing factors and stratifying risk favours surgery[5, 7].

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Limitations of the published literature include poor methodological quality, heterogeneity in patients studied, follow-up time, inclusion and exclusion criteria, surgical procedures and different scoring systems lacking sensitivity for patellofemoral populations[5, 9, 16]. The reliance on redislocation rates as the main outcome in most studies underlines the advantage of a more aggressive approach to restoring anatomy and improving patellar stabilization[5]. It is therefore not surprising in redislocation terms that surgery is supported. However, functional outcomes also suggest support for surgical intervention. The most commonly used PROM is the Kujala score, which does not capture disability following dislocation thoroughly[5, 16]. The activity level, symptoms of subjective instability, and quality of life have also been poorly reported[9].

Recent evidence supports a reduced redislocation rate and improved patient-reported outcomes when surgical treatment is used for skeletally mature patients with FTPD (3). Individualized surgery that considers patient age and predisposing factors may be the future gold standard for treating FTPD, but well-designed, comparative studies assessing adverse events and returning to sports are needed.

Author	**Year**	**Surgical Procedure**	**Outcome**	**N**	**F-up**	**Findings**
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Camanho	2009	MPFL repair	Recurrence rate, Kujala	33	3 y	Surgery superior all parameters
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Bitar	2012	MPFL reconstruction	Recurrence rate, Kujala	41	3.6y	Surgery superior all parameters
Petri	2013	MPFL repair	Recurrence rate, Kujala, patient satisfaction	20	2 y	No diference
Ji	2016	MPFL repair	Recurrence rate, Kujala, Subjective questionaire and radiological patellar tilt and shift	62	3.5 y	Better Kujala score and patelar tilt, rest no diferences

Table 1: Randomized control trials comparing operative and conservative treatments for patellar dislocation.

Level of Evidence: 2

References:

1. Askenberger M, Bengtsson Moström E, Ekström W, Arendt EA, Hellsten A, Mikkelsen C, Janarv P-M (2018) Operative Repair of Medial Patellofemoral Ligament Injury Versus Knee Brace in Children With an Acute First-Time Traumatic Patellar Dislocation: A Randomized Controlled Trial. Am J Sports Med 46(10):2328–2340
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15. Smith TO, Donell S, Song F, Hing CB (2015) Surgical versus nonsurgical interventions for treating patellar dislocation. Cochrane Database Syst RevDOI: 10.1002/14651858.CD008106.pub3
16. Watson R, Sullivan B, Stone A V., Jacobs C, Malone T, Heebner N, Noehren B (2022) Lateral Patellar Dislocation. JBJS RevDOI: 10.2106/JBJS.RVW.21.00159

Q11) Is nonoperative treatment the gold standard for treating FTPD in skeletally immature patients?

Statement:
Given the high recurrence rates in children, we cannot support nonoperative treatment as the gold standard for every patient. Skeletally immature patients with FTPD need to be thoroughly investigated to clarify the extent of predisposing factors. An individual redislocation risk estimation and a check for osteochondral or chondral fragments should be performed to stratify between surgical or nonsurgical treatment and extensively discussed with the patient and family. If the decision for nonoperative treatment is met, strict follow-up is mandatory.

Grade: C
Rating: median 9 (range 6-9)

Literature summary:

Lateral patellar dislocation (LPD) is the most common knee injury in children with traumatic knee hemarthrosis, with an annual incidence of 0.3 to 1.2 per 1000 in patients aged 9 to 15 years [3, 6, 10]. Seventy percent of patients 9-14 years of age with hemarthrosis after knee trauma had a serious intraarticular injury, and magnetic resonance imaging (MRI) is the key diagnostic tool [3]. The MPFL is frequently injured in FTPD patients who are skeletally immature, with the majority of MPFL injuries located at the patellar attachment compared with femoral-based lesions found in adults[1, 8, 16].

The incidence of osteochondral and chondral injuries is especially high in children, and 20% of FTPD patients have an osteochondral lesion >1cm^2 that needs surgery.
The recurrence rate in nonoperatively treated patients is approximately 30–70%, and this rate is greater in the youngest patients[4, 12]. When treating children with patellar dislocations, predisposing factors should be considered. Systematic radiological evaluation of anatomical abnormalities is essential when evaluating the risk of recurrent dislocations and when choosing the course of therapy[5].

The best method for treating traumatic patellar dislocation remains a subject of debate. Nonsurgical treatment has traditionally been advocated for patients with first-time traumatic patellar dislocation without substantial osteochondral lesions, although primary repair of the medial stabilizing structures was introduced during the 1990s[11, 15]. Surgery may reduce patellar instability, but a high incidence of degenerative changes in the patellofemoral joint has been reported at long-term follow-up[14].

There is a high level of evidence comparing both treatments in immature patients in three RCTs (Table 1) published between 2008 and 2018 with follow-up periods between 2 and 14 years[2, 12, 13]. The surgical procedure involved repair of the medial structures, and this procedure was found to be superior in two studies, with no difference reported in the study with longer follow-up[12]. No study identified a difference in functional results. The limitations of these studies are the small sample sizes and the use of different follow-up and functional scales.

In a long-term retrospective comparative nonrandomized study in skeletally immature patients who included 51 patients, 31 conservative patients and 11 surgical patients, the redislocation rates were 67% and 18%, respectively[9]. Despite the significant reduction in redislocation identified with operative intervention, knee function was not fully restored, and no significant difference in functional scores was observed between the surgically and no surgically treated patients. A recent case series in adolescent FTPD patients (9-18 years) who required surgery for a loose body compared those who underwent no additional treatment or concurrent MPFL repair with those who also underwent MPFL reconstruction. The MPFL reconstruction group was found to have a reduced rate of recurrent instability (19% versus 59%), improved return to sport (67% versus 39%) and reduced subsequent surgeries (7% versus 48%) compared with loose body removal in isolation or in combination with MPFL repair[7].

Surgical treatment should be considered for skeletally immature patients after FTPD among selected patients according to predisposing factors, given the high recurrence rate of nonoperative treatment. However, further high-quality studies stratified by the risk of dislocation are needed.

Author	**Year**	**Surgical Procedure**	**Outcome**	**N**	**F-up**	**Findings**	**Age (years)**
Palmu	2008	MPFL repair and lateral release	Recurrence rate, Kujala, Hughston, Tegner activity level	62 (28C/36 S)	14 y	High recurrence in both groups (71% in conserv. and 67% in surg. group) without differences. No differences in functional results	11-15 y
Regalado	2016	Roux-Goldthwaite	Recurrence rate, functional results (not reported scale) and satisfaction	36 (20 C/16 S)	6 y	Surgery superior in recurrence rate with significant difference of 33% vs 73% , rest no difference	8-16 y
Askenberger	2018	Arthroscopic MPFL repair	Recurrence rate, Kujala, KOOS-child, EQ-5D-, Tegner	74 (37 C/37 S)	2 y	Surgery superior in recurrence rate 22% vs 43%, with no difference in subjective and objective knee function with isokinetic test	9-14 y

Table 1: Randomized control trials comparing operative and conservative treatments for patellar dislocation

Level of Evidence: 2

References:

1. Askenberger M, Arendt EA, Ekström W, Voss U, Finnbogason T, Janarv P-M (2016) Medial Patellofemoral Ligament Injuries in Children With First-Time Lateral Patellar Dislocations. Am J Sports Med 44(1):152–158
2. Askenberger M, Bengtsson Moström E, Ekström W, Arendt EA, Hellsten A, Mikkelsen C, Janarv P-M (2018) Operative Repair of Medial Patellofemoral Ligament Injury Versus Knee Brace in Children With an Acute First-Time Traumatic Patellar Dislocation: A Randomized Controlled Trial. Am J Sports Med 46(10):2328–2340
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Q12) What is the role of bracing for nonoperative treatment in FTPD?

Statement:
There is no evidence for the superiority in the use of any bracing (as opposed to no bracing) in FTPD either in the acute or in the nonacute phase. Bracing with an unrestricted range of motion may only be considered in the acute phase after FTPD for a very short time.

Grade: B
Rating: median 9 (range 5-9)

Literature summary:

There is no consensus about the type and duration of immobilization, but most studies use some form of bracing and a variable time of immobilization[8]. The different modalities of conservative treatment can be roughly classified into two groups. One is 6 weeks of immobilization using a cylinder cast or removable splint to permit the healing of the medial retinaculum and soft tissues, encouraging fibrosis and the repair of stretched or ruptured stabilizing tissues[2, 5, 6, 8]. The other is functional mobilization after a short immobilization period using a simple brace to avoid the detrimental effects of muscle atrophy, thereby accelerating recovery[2, 5, 6, 8].

A systematic review and meta-analysis of 177 patients suggested that there is no significant difference in clinical outcomes when using a cylinder cast or posterior splint in full extension compared to an elastic bandage[8]. Van Gemert et al[1], in their systematic review, concluded that a posterior splint might be the best therapeutic option because of the low redislocation rates and knee joint restrictions. However, this recommendation is based on only one small study with significant limitations. In a more recent review, Vermeulen et al[9] concluded that the currently available literature on conservative treatment after a first-time patellar dislocation is scarce and of low quality, and conclusions should be drawn with care.

In a prospective RCT[6], eighteen patients over 18 years old with primary patellar dislocation and without accompanying fractures were included. After 1 week of dorsal splinting, they were randomised into two groups: those in which taping allowed 30-40^{o} of flexion or cylinder cast to complete 6 weeks in both groups. Taping resulted in a significantly better Lysholm score at the 6-week, 12-week and 5-year follow-ups. There were no cases of recurrent dislocation in either group. In a recent RCT comparing a motion-restricted knee brace (permitting 0-30^{o} knee flexion) against a neoprene nonhinged knee brace (allowing unrestricted movement) for 4 weeks, which included 79 patients, the redislocation rates were 34.5% and 37.5%, respectively, with no significant difference. Knee immobilization is associated with quadriceps muscle atrophy, reduced knee ROM, and worse functional outcomes in the first 6 months after injury[2]. However, no clinically relevant difference was found between the groups at 3 years.

In a multicenter study with a retrospective cohort of 601 subjects under 30 years of age distributed in different groups with two, four and six weeks of immobilization, 27% experienced redislocation, with no difference in the various immobilization periods[3]. The authors also concluded that increasing age reduced the risk of patellar dislocation. A retrospective study of a pediatric population with 142 FTPDs at a minimum of 1 year of follow-up comparing cast for 4 weeks, posterior splints for 4 weeks and braces with controlled mobilization for 6 weeks. The brace group had the lowest redislocation rate (8.6%)[4].

The classic and most cited study of Mäenpää el at[5] in a long-term nonoperative management of a cohort of 100 patients with FTPD treated with three different treatments: plaster cast, posterior splint, or elastic bandage with a mean time immobilization of 4, 3 and 2 weeks, respectively according to physicians' preference. The splint group had a lower rate of redislocation, a better Kujala score and

the lowest proportion of knee joint restriction, suggesting that the duration is as important as the type of immobilization. This study has many limitations but was among the first to compare these different treatments.

The use of elastic bracing results in dislocation rates similar to those of more restrictive immobilization[2, 8]. Biomechanically, it appears logical to avoid restraint of the knee close to extension in FTPD patients since this is where the patella is known to be least stable[7]. This approach also has the benefits of reducing associated muscle atrophy and improving knee range of motion[2]. Further high-level studies with modern braces and standardization of immobilization time and controlling variables, including age and predisposing risk factors, are required to confirm the most appropriate bracing protocol for FTPD patients.

Level of Evidence: 2

References:

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Q13) Is there any evidence for physiotherapy in FTPD patients?

Statement:
Despite the lack of strong scientific evidence for the benefit of physiotherapy in patients with FTPD, the consensus group recommends physiotherapy-guided exercises as a necessary supplement in operative or nonoperative treatment. Physiotherapy in FPTD patients is focused not only on quadriceps and gluteal muscle strengthening but also on motion exercises, gait re-education, functional neuromuscular control, and sport-specific training where indicated.

Grade: C
Rating: 9 range (5-9)

Literature summary:

Physiotherapy is widely used in the management of FTPD despite a lack of supporting evidence. A recent level 1 systematic review highlighted that despite high mean PROM scores following physiotherapy intervention in FTPD patients, preinjury knee function is not restored[6]. A retrospective cohort study revealed that rehabilitation had no significant effect on the rate of patellar redislocation[3], findings supported by other studies[6]. Furthermore, no studies examining physiotherapy have included a "no intervention" control group, meaning that its overall effectiveness cannot be compared with the natural history of the condition.

Logically physiotherapy for FTPD patients should help address deficiencies likely to increase knee valgus and rotation (e.g., excessive femoral adduction and internal rotation, tibial rotation, and foot pronation) since this is a known risk factor for patellar dislocation[7]. A combination of open- and closed-chain lower limb exercises for the quadriceps and hip abductor muscles, in addition to proprioceptive exercises, has been recommended[6]. Given the lack of literature on physiotherapy in FTPD patients, data from patellofemoral pain patients have been extrapolated to make recommendations for FTPD patients[12]. This approach has limitations since risk factors, including unfavourable bony geometry, may be greater in dislocation populations. Biomechanical studies have outlined how knee valgus could be driven by underlying bone geometry (e.g., femoral or tibial torsion)[11]. The presence of bone torsion alters the effectiveness of lower limb musculature; for example, femoral anteversion reduces the lever arm of the gluteus medius (the primary hip abductor), placing it at a disadvantage and meaning that the muscle must work harder to be as effective[1, 11]. Physiotherapy may therefore be more successful in patients with fewer anatomical risk factors for redislocation.

Quadriceps strengthening is the most widely investigated intervention with the highest-level evidence[6]. An RCT revealed that quadriceps strengthening was not significantly different from medial vastus strengthening at 12 months in patients with primary patellar dislocations[8]. The high dropout rate of more than 50% in this study highlights the challenges in this field. Gluteal and quadriceps muscle weakness and ankle stiffness were identified in primary patellar dislocators in a case–control study, suggesting benefits from flexibility and strengthening programs for these patients[2]. There is no clear consensus on the definition of optimal rehabilitation following primary patellar dislocation[9]. Management typically includes range of motion exercises, gait re-education, techniques to promote soft tissue flexibility, functional neuromuscular control, strengthening exercises and sport-specific interventions where indicated[5, 6, 10]. Intervention protocols are often varied, poorly defined and difficult to compare – variabilities in exercise dosage (sets, reps, load and rest times) are often not described, rendering study replication and comparison impossible[6]. The lack of consensus and limited treatment success suggest that deficits in these patients are not presently adequately understood or addressed, and further studies are required in this field[4].

There is no evidence-based return to sport protocols to guide safe resumption of activity for this population. Similarities between rehabilitating patellar dislocators and ACL-injured populations (for whom there is significantly more evidence) have been suggested and are logical given the valgus collapse demonstrated by both groups[5]. For example, changes in the direction of drills in dislocation patients during end-stage rehabilitation are important since this often occurs when instability occurs[7].

Currently, there is a lack of evidence to support the use of physiotherapy in FTPD; quality cluster randomized studies with comparable groups and functional outcomes are warranted. However, physiotherapy to address deficiencies likely to increase knee valgus and rotation resulting from functional deficiencies such as quadriceps and gluteal weakness may be indicated, particularly in those patients with fewer risk factors for redislocation. Physiotherapy in this group needs further investigation since there is currently limited evidence to support it being superior to leaving patients to natural progression[4].

Level of Evidence: 3

References:

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Q14) In which cases should surgical treatment be considered in skeletally mature patients?

Statement:
In skeletally mature patients, the individual analysis of risk factors and the estimation of recurrence risk using one of the published scoring systems and/or ongoing symptoms or osteochondral lesions should be the basis for decision making. Therefore, primary surgical reconstruction needs to be considered a first option in patients with several risk factors and ongoing symptoms or osteochondral lesions, ultimately changing the old paradigm of first line nonoperative treatment in all patients. The pros and cons of surgical versus nonsurgical treatment need to be carefully discussed with the patient.

Grade: C
Rating: median 9 (range 6-9)

Literature summary:

The incidence of FTPD and its recurrence are highly variable, depending on the selected patient groups and administrative data sets used[3, 8, 11, 21, 23, 24]. Every FTPD has its own characteristics regarding injury mechanism, injury pattern, and the presence of anatomic patellar instability risk factors,

including an inherent risk of further dislocating events, cartilage lesions, and osteoarthritis in the long term[2, 25, 27].

As the number of factors present in a single patient increases, the risk of experiencing recurrent dislocation also increases[1, 4, 6, 13–16, 18, 19, 26] (Table 1). The main factors that predispose patients to recurrent dislocations are young age/open physis, trochlear dysplasia, patella alta, distal malalignment, and contralateral instability[1, 4–6, 9, 10, 12–16, 18, 19, 22].

In a systematic review, Stefancin and Parker[23] reported a mean redislocation rate of 48% (38%-57%) after nonoperative treatment. The redislocation rate decreased to 17% following various surgical techniques. It was concluded that primary surgical treatment after FTPD should be considered in patients with substantial disruption of the medial patellar stabilizers or a laterally subluxated patella with normal alignment of the contralateral knee or in patients who do not improve with appropriate rehabilitation. Further indications included a second dislocation of the patella and the presence of an osteochondral fracture (not discussed in this chapter).

In 2019, Pagliazzi et al.[20] published a meta-analysis of surgical versus nonsurgical treatment of FTPD and confirmed a greater redislocation rate with the nonsurgical approach and more favourable clinical outcomes with the surgical approach during short- and midterm follow-up (6 years). At longer follow-up, however, the results were similar for the surgical and nonsurgical groups.

Focusing on MPFL reconstruction techniques, Cohen et al.[7] reported redislocation rates of only 7% in the operatively treated group vs. 30% in the rehabilitation group. This was accompanied by a higher Kujala score in the surgically treated group (81 pts. vs. 87 pts.), and there were no differences in patellofemoral pain between the groups. These findings are in line with another systematic review of 12 studies that reported significantly improved Kujala scores after MPFL reconstruction compared with nonoperative treatment in patients with both FTPD and recurrent dislocations[17]. All analyses included skeletally mature and immature patients without stratifying results according to patient age. However, the low redislocation rates after MPFL reconstruction support the consideration of early reconstruction, taking individual risk stratification models into account.

Table 1: Risk of recurrence considering the prevalence of concurrent risk factors

Study	Risk factors	No.of risk factors				
		0	1	2	3	4
Lewallen et al. (14)	Patella alta Trochlea dysplasia Age < 25 years	8,6%	11,1-26,6%	29,6-60,2%	70,4%	
Arendt et al. (19)	Open physis Sulcus-angle > 154° Patella alta (Insall–Salvati ratio > 1.3)	7,7%	22,7%	50,9%	78,5%	
Jaquith & Parikh (15)	Trochlear dysplasia Contralateral instability Patella alta (Caton-Deschamps ratio > 1.45)	13,8%	30,1%	53,6%	74,8%	88,4%
Martinez-Cano et al. (11)	Severe Trochlear dysplasia (Dejour Typ B-D) Age < 21 years Caton-Deschamps ratio ≥ 1,15	31,2%	36,6%	71,7%	86,2%	

	Observed Recurrent Instability-Free Survival		1year	2 year	5 year	10 year
Hevesi M et al. (20)	Age <25 years Skeletal immaturity Dejour A-D dysplasia TT-TG/PL (Total 0 – 5 points)	Low-risk (0-1) Intermediate risk (2-3) High-risk (4-5)	100 83,3 84,4	100 72,2 62,5	100 69,4 34,4	100 69,4 20,8

Level of Evidence: 2

References:

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Q15) In which cases should surgical treatment be considered in skeletally immature patients? Are there any specific clinical concerns in skeletally immature patients after FTPD?

Statement:
There is a greater incidence of persistent symptoms after FTPD, especially among skeletally immature patients than among skeletally mature patients. Therefore, the risk for further instability and thereby a greater risk of cartilage deterioration and loss of knee-related quality of life are substantial among adolescents. Current individualized (á la carte) surgical techniques demonstrate good outcomes in patients with open growth plates. Due to high recurrence rates and age itself being a risk factor, surgical treatment should be discussed with patients and families for every skeletally immature patient. The decision should be made respecting the individual risk for instability, ongoing symptoms and/or osteochondral fragments and patient demands.

Grade: C
Rating: median 9 (range 5-9)

Literature summary:

The incidence of FTPD tends to be the highest among active adolescents and athletic cohorts[5, 11]. In a recent long-term study, the cumulative incidence of recurrent dislocation in skeletally immature patients was 11% at 1 year, 21.1% at 2 years, 37.0% at 5 years, 45.1% at 10 years, and 54.0% at 15 years[11]. Previous studies also reported a recurrence rate of up to 50%-70% in children and adolescents[2, 9].

Although sex and MPFL injury pattern were nonsignificant factors for experiencing patellar redislocation, young age/skeletally immature status was found to be a significant risk factor in nearly all risk stratification models considering patellar instability recurrence (please see Table 1, Question 18).

As highlighted above, analyses by Cohen et al. and Liu et al. (Ref. No. 28 and 29; Question No. 18) included skeletally mature and immature patients without stratifying results according to patient age. However, the lower redislocation rate after MPFL reconstruction than after rehabilitation is striking. This finding was also confirmed by a recent study published by Schlumberger et al.[12]. The authors evaluated 45 MPFL reconstructions in skeletally immature patients with recurrent LPD or an FTPD with either an additional intraarticular injury (chondral or osteochondral fracture or lesion) or the presence of risk factors for recurrent dislocation. After 4.3 ± 1.7 years (range, 2.0-7.3 years), redislocation occurred in 3 patients (6.7%). The mean Lysholm and Kujala scores at follow-up were 95.9 ± 7.4 and 97.9 ± 7.1, respectively.

Focusing on skeletally immature patients, Shamrock et al.[13] evaluated 132 MPFL reconstructions in patients with a mean age of 13.2 years (range, 6-17 years). The results suggested that MPFL reconstruction in skeletally immature patients is a viable treatment option, with significant improvement in patient-reported outcomes and redislocation rates of less than 5% at nearly 5 years of follow-up. Similarly, D'Ambrosio et al.[3] concluded that MPFL reconstruction in young patients can be considered an effective and safe treatment leading to clinical improvement in terms of the recurrence of dislocation (5%). However, both systematic reviews were performed on recurrent patellar instability, which limits their transferability to FTPD.

Surgical treatment of FTPD in children and adolescents was associated with a lower risk of recurrent dislocation[4, 8] and was, in some investigations, also associated with higher health-related quality of life and sporting function considering various surgical treatment procedures[8]. MPFL reconstruction appears to be beneficial in skeletally immature patients with redislocation rates comparable to those of adults. However, there is a paucity of evidence on MPFL reconstruction for FTPD in the skeletally immature population.

FTPD is most common during the growth spurt, when the muscles, neuromuscular adaptations and length are not in perfect harmony. Physiotherapy can be a good first-line treatment but should be controlled with meticulous follow-up evaluations. Like for anterior cruciate ligament injuries in children, patients learn how to rehabit and are mentally prepared if surgery becomes necessary. As in adults, the low redislocation rates after MPFL reconstruction support the consideration of early reconstruction, taking individual risk stratification models in coordination with the patient's demand into account. Due to the multifactorial nature of the PFI and the paucity of prospective paediatric studies, it is still difficult to draw distinct conclusions. We can only assume which patients need early surgery using different scores, but where the cut-off occurs when a single pathoanatomic factor is considered relevant and which one needs to be corrected surgically needs more investigation[1].
Several studies have shown that MPFL reconstruction is a good and safe method, even for children with open growth plates, and can be safely performed when femoral insertion is maintained at Schottle´s point with radiological control to spare the physis, and drilling in small patellae is avoided[6, 7, 10].

Level of Evidence: 3

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Q16) Is there a role for medial patellofemoral ligament (MPFL)/medial patellotibial ligament (MPTL) repair vs. reconstruction in acute cases?

Statement:

MPFL reconstruction has demonstrated clinical superiority compared to medial soft tissue repair techniques (MPFL/MPTL repair). Therefore, when MPFL surgery is indicated for patients with FTPD, MPFL reconstruction is the method of choice to address the medial soft tissue stabilizers.

Grade: C

Rating: median 9 (range 6-9)

Literature summary:

Several studies have shown that the medial patellofemoral ligament (MPFL) is the primary constraint preventing lateralization of the patella[14, 15, 26, 41]. The MPFL is a thin ligament that inserts at the proximal two-thirds of the medial border of the patella. At the femur, the MPFL inserts at the bony prominence between the medial femoral epicondyle and the adductor magnus tendon. It has been reported that in more than 90% of cases of traumatic patellar dislocation, the MPFL is torn, and sometimes the medial patellotibial ligament (MPTL), a secondary patellar supporting structure, is also injured[13, 37, 41, 42, 46, 47, 50, 51, 60, 63]. The tear might be complete or partial, at the patellar insertion, at the femoral insertion or in the midsubstance of the MPFL. The injury locations of MPTL patients have not yet been defined in the literature. While many authors have reported that the most common tear of the MPFL is at its femoral attachment[37, 46, 52, 63], there are also some references reporting that the patellar attachment is the most common site of MPFL tear[17, 21, 42, 50]. It seems that age correlates with the site of the MPFL injury location and, more precisely, that younger patients most often sustain ruptures at the patellar insertion, while older patients most often sustain ruptures at the femoral insertion[42, 50]. The MPFL/MPTL injury location cannot be diagnosed arthroscopically, and MRI is the method of choice for the diagnosis of MPFL injury[6]. MRI is always recommended for first-time patellar dislocation (FTPD) to verify the diagnosis and the exact MPFL injury pattern and to evaluate additional injuries. Because of the high prevalence of osteochondral fractures[28], MRI is recommended for patients with FTPD.

The optimal treatment modalities for FTPD remain controversial. Despite randomized clinical studies, various factors affecting patellar stability have not been defined with a good level of evidence and a sufficient number of patients studied. Although many authors suggest conservative treatment after FTPD, several circumstances may warrant surgical intervention. These circumstances include an osteochondral fracture suitable for surgical repair to prevent cartilage integrity and major injury of the medial patellar stabilizing structures with irreducible or permanent subluxation of the patella. Some patients are at major risk of redislocation and subsequent complaints if multiple risk factors for recurrence are present (bone abnormalities, including trochlear dysplasia or patella alta)[5]. A major controversy is whether surgical treatment can improve clinical outcomes in high-risk patients and which kind of surgical management should be used after FTPD in patients with bony abnormalities.

Based on the aforementioned findings and especially considering that the MPFL is torn in more than 90% of patients with FTPD, several investigators have described the results of performing MPFL repair after FTPD. Some of them are technical notes[1, 19, 22, 25, 27, 30, 48, 61] describing various techniques for repairing the medial structures either at the patellar attachment or at the femoral insertion of the MPFL performed in an open or arthroscopic manner, and sometimes the authors combined these technical notes with short-term follow-up, such as case series[55]. The majority of studies are Level of Evidence IV or III[2, 3, 8, 9, 23, 24, 32, 38, 49, 59]. Theoretically, repair of the injured MPFL or medial stabilizing complex should be the preferred surgical option.
Surgical stabilization of the patella can be achieved via MPFL repair or reconstruction. MPFL patellar or femoral attachment injury can be surgically reinserted with satisfying results and may lead to a better outcome than nonsurgical treatment[7], although some controversy exists in the results of prospective studies[13, 40, 53]. MPFL midsubstance injuries do not seem to benefit from acute repairs[34, 40, 52]. MPFL injury at the femoral or patellar attachment can be repaired with sutures or suture anchors[7, 13, 54]. Midsubstance MPFL injury is difficult to repair adequately and is therefore not recommended[34, 40, 52, 53]. Multiple injuries to the medial patellar stabilizing complex have been reported to be found in MRI[58], indicating that the repair of certain MPFL or MPTL injury locations is unreliable for fully restoring patellar stability. Given the variety of injury locations and the reported less favourable clinical outcomes for repair, MPFL repair cannot be recommended as a surgical solution, whereas MPFL reconstruction is the method of choice.

Several well-designed studies (level of evidence II or I) concerning the role of medial structure repair in FTPD[10, 13, 35, 36, 40, 43, 44, 52, 53] have been published. In a level I study, Sillanpaa et al.[51] reported no redislocations in the operative group but no other benefits for the initial repair, such as subjective knee scores or a return to a high activity level. In addition, Camanho et al.[11], in a level II study with a short-term follow-up (mean follow-up of 2 years), reported the superiority of MPFL repair over conservative treatment in treating FTPD considering both the redislocation rate (0% vs 50%) and clinical outcome. When considering children and adolescents, Apostolovic et al.[3] exclusively did not find any significant differences in the subjective outcome or in the redislocation rate between early repair of medial structures and nonoperative treatment in a study of 37 patients. The follow-up of this study was long, with a mean of 6.1 years. Similarly, in a level I study concerning only patients under the age of 16 years, Palmu et al.[40] compared medial structure repair versus conservative treatment with 14 years of follow-up and found no significant differences in the subjective outcome or redislocation rate. Primary repair of the torn medial retinacular structures in this age group did not improve the subjective or functional long-term results. In addition, the redislocation rate did not differ between the 2 groups (67% vs 71%). Therefore, this surgical approach cannot be recommended for paediatric patients.

More recent studies during the past five years have shown a tendency toward better outcomes in surgical vs nonoperative treatment[4, 16, 20, 29, 31, 33, 45, 62, 64]. Previous systemic reviews and meta-analyses concerning the best treatment option for FTPD [12, 18, 39, 56, 57, 65], which are based on more traditional approaches to treating FTPD, including the lack of awareness of the location of MPFL injury and the use of MPFL repairs instead of reconstruction, are less favourable for the surgical management of FTPD, especially in regard to patient-reported outcomes. Most reviews reported lower redislocation rates in surgically managed FTPD versus non-operated patients. In most of these meta-analyses, the authors noted the high risk of inherent bias due to the small number of patients and lack of reporting of the prevalence of risk factors for recurrent instability and emphasized the persistent need for better-designed randomized studies. Smith et al.[56], in a Cochrane meta-analysis, concluded that compared with nonoperative treatment, operative treatment for FTPD is associated with a significantly greater risk of patellofemoral joint osteoarthritis but reduces the risk of subsequent patellar dislocation. It should be noted, however, that the authors emphasize the heterogeneity of both conservative and surgical treatment in the studies they analysed.

The conclusion of all the systemic reviews and the meta-analyses can be considered as there is insufficient high-quality evidence to confirm any significant difference in outcome between surgical or nonsurgical initial management of people following FTPD. In recent years, however, the heterogeneity of the FTPD dislocation population is better understood and therefore, more detailed analysis of preferred and individualized treatment modalities is needed, not as a mass recommendation for all FTPD patients. Patellar instability severity score analysis, based on reported risk factors for recurrent patellar dislocation, should be used[5]. In FTPD patients with a normal or minor dysplastic patellofemoral joint, nonoperative treatment is recommended. Any FTPD patient should undergo MRI, the preferred imaging modality, to diagnose any osteochondral fracture amenable to surgical repair to prevent cartilage. If surgery is necessary, in the case of an osteochondral fracture or in an FTPD patient with multiple risk factors for recurrent patellar dislocation, MPFL reconstruction, the method of choice, is more reliable for clinical outcomes than is medial repair. There is no current high-level evidence, and no study has compared MPFL reconstruction versus repair or MPFL reconstruction only versus associated bony procedures in FTPD patients with trochlear dysplasia or other significant PF joint abnormalities. Patients with major abnormalities in PF joint anatomy may benefit from surgical correction, but whether bony abnormalities should be addressed in FTPD to minimize the risk of redislocation has not been studied. The lack of definitions for significant bony abnormalities and threshold values affecting the outcome of treatment for FTPD remains a challenge.

Level of Evidence: 2

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Q17) Has MPFL reconstruction a better outcome than MPFL repair?

Statement:
Comparative studies are very heterogeneous in terms of demographics, risk factors and surgical techniques and are not limited to patients with FTPD. With today's knowledge of individualized treatment regarding risk factors and skeletal maturity taken into consideration, MPFL-reconstruction has a better outcome than MPFL-repair.

Grade: C
Rating: median 9 (range 6-9)

Literature summary:

First, it should be noted that the large body of available literature is characterized by marked heterogeneity regarding reported demographics, descriptions of anatomical and radiographic risk factors, different surgical techniques and outcome scores. The situation is further complicated by the distinction between FTPD and recurrent dislocation and the treatment of children and adults, some of whom were treated overlappingly, and studies often do not differentiate those parameters when reporting results. Since it is not possible to comprehensively review the whole body of literature, this chapter will draw on the available systematic reviews and meta-analyses, which attempt to represent the situation as broadly as possible.

Liu et al.[3] conducted a systematic review and meta-analysis to determine the efficacy and safety of 3 treatments in the therapy of patellar instability, comparing the effects of MPFL reconstruction with those of MPFL repair, MPFL reconstruction with nonoperative treatment, and MPFL repair with nonoperative treatment. Twelve studies were eligible for inclusion, five of which compared MPFL reconstruction and MPFL repair in patients with >1 dislocation. The results indicated that compared with MPFL repair, MPFL reconstruction led to significantly reduced redislocation and improved Kujala scores.

Considering randomized and nonrandomized comparative trials, Previtali et al.[4] sought to compare the results between MPFL reconstruction and other medial patellofemoral soft-tissue surgeries after recurrent lateral patellar dislocations in the absence of untreated predisposing factors (such as high-grade trochlear dysplasia, knee malalignment, patella alta or high tibial tubercle-trochlear groove distance). Overall, six studies involving 319 knees were included in the meta-analysis. Analyses of redislocation (0.7% vs 2.9%) and minor complication rates (12% vs 9%) revealed no significant differences between MPFL reconstruction and other medial soft-tissue surgeries. Significant differences favouring MPFL reconstruction were detected in the Kujala and Lysholm scores at short-term and long-term follow-ups, but no significant differences were detected between the International Knee Documentation Committee and Tegner scores. The authors concluded that both MPFL reconstruction and medial patellofemoral soft tissue surgery were effective in restoring the medial restraining forces preventing redislocation (in the absence of untreated predisposing factors), but MPFL reconstruction provided better functional outcomes both at short-term and long-term follow-up.

Hurley et al.[1] performed a network meta-analysis of randomized controlled trials (RCTs) to compare MPFL reconstruction, MPFL repair, and nonoperative management for patellar instability. Thirteen RCTs were included, three of which directly compared MPFL reconstruction with MPFL repair. In addition, this analysis was capable of a subgroup analysis of patients with FTPDs. The findings of this analysis showed that MPFL reconstruction had the highest P score and resulted in a significantly greater Kujala score than nonoperative management but not MPFL repair. Subgroup analysis revealed that MPFL reconstruction had the highest P score for all outcomes (redislocation rate; Kujala score) in those with FTPD.

Jiang et al.[2], in a level IV systematic review and meta-analysis, investigated the clinical outcomes of MPFL reconstruction, MPFL repair and medial reefing, focusing on patients with FTPD. Twenty-two studies involving 668 patients were included, of which four studies involving 126 patients were in the MPFL reconstruction group, ten studies involving 220 patients in the MPFL repair group, and 9 studies involving 322 patients in the medial reefing group. The results showed that the rate of postoperative redislocation and reoperation were significantly lower for MPFL reconstruction (1.8%, 95% CI – 0.5 to 4.0%) than for MPFL repair (15.4%, 95% CI 5.2-25.7%) and medial reefing (18.0%, 95% CI 9.3-26.7%). In addition, no significant differences were found in the Kujala score or complication rate among the three treatments. Although MPFL reconstruction could achieve a significantly lower redislocation rate and reoperation rate than MPFL repair and medial reefing after FTPD, the available evidence has demonstrated that there is not enough evidence to reveal that MPFL reconstruction provides better functional outcomes than MPFL repair and medial reefing.

The purpose of the study presented by Wilkens et al.[5] to identify all available evidence on recurrent patellofemoral instability rates after MPFL reconstruction techniques and other soft tissue realignment techniques in skeletally immature patients. Twenty-one articles were found to be eligible for this systematic review and meta-analysis. Ten studies reported on MPFL reconstruction techniques using different graft and fixation techniques, and 11 reported on other soft tissue realignment procedures. In total, 62 of the 448 (13.8%) treated knees showed recurrent patellofemoral instability during follow-up. There was a large variation in reported recurrent instability rates, varying between 0 and 38% for MPFL reconstruction techniques and between 0 and 82% for other soft tissue realignment techniques. For MPFL reconstruction techniques, the pooled recurrent patellofemoral instability rate was estimated to be 0.02 (95% CI 0.00–0.09). For the other soft tissue realignment techniques, the pooled rate was estimated to be 0.15 (95% CI 0.04–0.31). No statistically significant difference in recurrent patellofemoral instability rates between MPFL reconstruction techniques and other soft tissue realignment techniques was found (χ^2= 3.04).

In patients with >1 dislocation, the MPFL-R increasingly showed clear advantages in terms of the redislocation rate and functional outcome compared to those of other soft-tissue procedures, at least when the Kujala score was used as the outcome parameter. Other patient-reported outcome measures (e.g., IKDC, Tegner score) are not as clear in this regard. Similar results have also been found in the treatment of patients with FTPD, despite the use of smaller datasets. However, in FTPD, the postoperative functional outcome scores of MPFL-R are not necessarily superior to those of other soft-tissue techniques. In addition, in children and adolescents, no statistically significant difference was found in recurrent instability rates between the MPFL-R technique and other soft tissue realignment techniques.

Level of evidence: 4

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Q18a) When is isolated MPFL reconstruction indicated in FTPD?

Q18b) Should combined corrective surgery (MPFL + additional procedure) be considered for treating FTPD in the presence of (bony) anatomic abnormalities?

Statement:
Despite the lack of clear scientific evidence supporting these questions, the consensus group supports isolated MPFL reconstruction in the absence of relevant bony risk factors and, vice versa, the correction of relevant bony risk factors in addition to MPFL reconstruction after FTPD. As it was shown for redislocations, untreated bony risk factors increase the risk of failure. For this reason, it is only consistent to correct relevant bony abnormalities at the earliest possible chance to avoid recurrence and revision surgery. The exact cutoff for relevant bony abnormalities is under debate, and therefore decision is always individual.

Grade: D
Rating: median 9 (range 7-9)

Literature summary:

In the past, surgical treatment of FTPD was limited to patients who presented with loose bodies, large osteochondral fragments, or irreducible dislocations. Most of the procedures involved in repair of the medial retinacular structures (medial reefing or direct repair) are associated with various soft tissue procedures, such as VMO plasty and lateral release, and the treatment of chondral/osteochondral injuries[4]. The evolution of knowledge and surgical techniques for recurrent patellar instability has also led to the introduction of MPFL reconstruction in the treatment of FTPD [3, 13]. Compared with MPFL repair, this “reconstructive approach” significantly improved clinical results (i.e., Kujala, Lysholm, and Tegner scores)[10, 12, 18]. These results can be attributed to the increased reproducibility and reliability of the technique and because MPFL reconstruction treats femoral-sided MPFL lesions, which are more difficult to repair and are associated with a greater recurrence rate[1, 15]. In terms of recurrence, compared with conservative treatment or MPFL repair, MPFL reconstruction has been proven to be significantly more effective at reducing the risk of redislocation[2, 5, 14].
However, the current literature is still inconclusive regarding the indication and need for concomitant bony correction in addition to MPFL-R. Several studies aimed to identify certain risk factors crucial for patient-reported outcomes and postoperative patellar stability. However, the significance of these risk factors relevantly varies among studies[6]. For example, Erickson et al.[7] reported good to excellent outcomes after isolated MPFL-R in a bony pathonanatomy setting. Similarly, Liu et al. reported no difference in the outcomes after MPFL-R between patients with and without trochlear dysplasia[11]. On the other hand, Zimmermann et al.[19] looked at reasons for MPFL-R failure and reported that recurrent instability was associated with the prevalence of severe trochlear dysplasia, valgus deformity, and increased patellar height. Likewise, Hopper et al.[9] observed recurrent instability in all patients with severe trochlear dysplasia, and Zhang et al.[17] reported inferior outcome scores in patients with increased femur antetorsion, and Franciozi et al. showed that the use of the MPFL-R in

combination with medialization of the tibial tuberosity at an increased TT-TG distance leads to a better clinical-functional outcome than the use of the isolated MPFL-R[8].

Given this natural heterogeneity in patients with lateral patellar instability and inconsistencies in reporting risk factors for MPFL-R failure, many published articles have limited applicability when reporting results after isolated MPFL-R[6, 16]. As a synopsis of the available literature, a recent systematic review concluded that severe trochlear dysplasia and femoral tunnel malpositioning appeared to be the most important parameters affecting postoperative patellofemoral stability and patient-reported outcomes after MPFL-R surgery[6]. Thus, it seems likely that at least some of the known pathoanatomic risk factors affect patellofemoral stability and patient-reported outcomes after patellar stabilizing surgery. However, the current literature lacks the opposite conclusion: in those patients, the correction of modifiable risk factors led to better results than an isolated MPFL-R, particularly when considering results after FTPD.

Level of Evidence: 4

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Q19) In case combined procedures are necessary, should these be done simultaneously or staged?

Statement:
Despite a lack of literature data, the consensus group supports the single-stage correction of relevant instability factors whenever needed and possible. In selected very complex cases (such as derotation osteotomies), a staged procedure may be an option. Uncorrected risk factors may have a negative influence not only in terms of recurrence or knee-related quality of life but also deteriorate the result of already addressed reconstructions. There are no clear cut-off values available to indicate these combined procedures.

Grade: D
Rating: median 9 (range 8-9)

Literature summary:

Various surgical procedures have been described to stabilize the patella. Most commonly, MPFL reconstruction is the method of choice for surgical stabilization[11]. To address the most common risk factors for recurrent patellar instability, additional surgical procedures that alter the bony anatomy of the patellofemoral joint have been introduced[2, 4, 10, 12, 14]. Trochleoplasty can be used to correct trochlear dysplasia, various tibial tubercle osteotomies can be used to correct patellar malalignment, and valgus or derotational osteotomies can be used to correct frontal and rotational lower limb abnormalities[3, 5, 7, 8, 17, 18]. Most bony procedures are believed to be necessary in the case of severe bony abnormalities[1, 6, 15]. To date, the literature does not support any specific threshold values in these abnormalities whether surgery is warranted or not, despite the fact that these abnormalities may play a role in individual dislocation prognosis[11, 17]. The challenge remains in not being able to generalize the significance of the factors in the common patellar instability population.

Whether concomitant bony correction is considered necessary in addition to MPFL reconstruction, the general recommendation among patellofemoral experts is to perform MPFL reconstruction and bony procedures simultaneously. The recommendation is based on the fact that severe bony abnormalities, increasing the risk of recurrence, not addressed primarily when isolated MPFL reconstruction is performed, may lead to poorer outcomes and the need for subsequent surgery[1, 6, 9, 13, 16].

Therefore, patient exposure to secondary surgery increases the risk of surgical comorbidities and should be avoided by an individualized single-step surgical approach instead of staged surgery. However, combination procedures for patellar stabilizing surgery have not been studied in regard to which surgical procedures provide the best results.

Level of Evidence: no studies available

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Q20a) Which osteochondral or chondral fragments need surgery?

Statement:
To achieve the highest possible degree of knee restoration, at least osteochondral or chondral fractures should be repaired if the defect is in the patellofemoral articular area and equal to or larger than 1cm^2. Depending on the flake characteristics, one can consider fragment refixation or other cartilage restoration techniques.

Grade: C
Rating: median 9 (range 7-9)

Q20b) Which FTPD patients need immediate surgery? When should delayed surgery be considered?

Statement:
Even when repairing a chondral or osteochondral lesion at the earliest possible timepoint is preferable, delayed refixation or repair rather than fragment removal should be considered. The patient workup (esp. imaging) should ideally be performed before this acute surgery to understand the risk factors and to have the option to add concomitant procedures if necessary. In the absence of repairable chondral or osteochondral injuries, immediate surgery is not necessary.

Grade: D
Rating: median 9 (range 7-9)

Literature summary:

Treatment options must consider the size, cartilage integrity, location, and chronicity (acute or chronic injuries) of the OCF[1]. In FTPD, the chondral or osteochondral fragments can range in size from small, comminuted pieces to hemicondylar avulsions. In therapeutic decision-making, the relationship between the size of the focal osteochondral defect and the potential development of osteoarthritis should be considered, although this relationship has not yet been fully clarified[3]. A study by Guettler et al. showed that a size threshold of 10 mm, based on biomechanical data, may be a useful adjunct to guide clinical decision making. Cartilage damage greater than 1 cm² has been reported to increase the risk of joint degeneration[3]. Thus, fixation has the advantages of potentially restoring normal patellofemoral articulation and decreasing the risk of long-term osteoarthritis[3, 10], which is highly important for larger defects and bearing surfaces. However, there is a lower limit in the size and quality of the fragment that makes refixation possible. According to previous reports, a fragment size >5x10 mm can be fixated properly by an experienced surgeon[17].

Beyond size, the quality of the fragment must also be considered. The presence of subchondral bone has traditionally been considered preferable for successful refixation, which is based on the belief that the avascular nature of the chondral tissue has poor healing potential. However, some studies have shown that many of the supposedly pure chondral fragments contain minimal bone (<5 mm)[2, 4, 6], and some reports have also demonstrated the healing potential of purely chondral fragments[2, 4, 22].

Regarding location, it is plausible to affirm that an OCF in a weight-bearing area, if it is of a size and quality that technically allows appropriate fixation, has advantages if it is repaired[7, 10, 12, 17–19]. The OCFs not amenable for fixation, in the weight-bearing area or not, are managed surgically with removal of the fragment by some authors and non surgically by others. Those who indicate surgery involving removal of the fragment not amenable for fixation advocate that intra-articular loose bodies are associated with poor results for conservative or late surgical treatment[21]. Nonsurgical treatment of these OCFs is advocated by others, especially in low- or non-weight-bearing areas, placing the surgical indication in the nonacute phase if loose bodies develop mechanical symptoms[12, 18, 20]. Overall, modern techniques involving the use of cartilage restoration procedures may be considered,

especially for fragments not amenable to refixation in weight-bearing areas, to mitigate later complications[9, 10, 16, 18, 19, 21].
OCFs that do not involve the weight-bearing area but are large enough to be repaired are considered more difficult decisions and less clarified. Fixation can restore the normal patellofemoral joint, but surgical complications, such as possible fragment necrosis[13], possible injury to the cartilage by fixation implants, increased surgical trauma and operative time and increased risk of infection, may negatively affect the outcome of fixation[5, 10]. Notably, the studies of Lee et al.[9] and Kang et al.[5] showed that for OCFs that are smaller than 2 cm^2 and do not involve the bearing surface, the excision of OCFs has equivalent or better outcomes than fixation in adolescent patients. On the other hand, Gesslein et al. reported better mid- to long-term outcomes after OCF than after debridement[8].

The time between injury and treatment is clearly of interest because of the healing potential of the displaced fragment. Although the literature on the precise definition of acute or chronic injury is scarce, acute injury is commonly defined as less than 2 weeks[1]. The impact of time from injury to refixation was previously identified as an important issue[14, 15]. Although this subject has not yet been fully clarified, the argument is that the diagnostic delay could compromise the physical properties of the fragment and, eventually, limit cell viability, thus reducing the possibility of fixation and anatomical repair[7, 11, 13, 23]. The regeneration capacity of the cartilage is limited, and the defect begins to fill with fibrocartilage within 10 days after the injury. For these reasons, fragment fixation is traditionally performed in the acute setting within 2 weeks of injury[7, 10, 12, 15, 16, 19]. Historically, nonacute displaced fractures (> 15 days old), neglected or missed, were considered loose bodies and excised and may require a regenerative procedure at the defect site if necessary[11, 15]. However, studies including children aged between 12 and 16 years reported successful repair of OCFs with fragment fixation in a nonacute setting. The time from injury to refixation varied between 4 weeks and 1 year[2, 4, 14]. In addition, more recent investigations have shown that surgical delay should not principally be considered a predictor of poor outcomes. In comparative studies, refixation of chronic lesions (with the chronicity threshold set at 4 and 6 weeks) achieved the same healing rate as refixation of acute lesions.

In conclusion, some authors always put surgical indications in the acute setting in the presence of OCFs, either for repair or for removal of the fragment. Others believe that if the OCF is not amenable to fixation, it can be managed non surgically, especially when the fracture is in a low weight-bearing area. Although early diagnosis and early fixation appear preferable, in cases of late presentation, especially in young patients, fixation can be achieved with good results; therefore, the integrity and cartilage status of the fragment should be considered.

Level of Evidence: 4

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Q21) Are there any differences between skeletal mature and immature patients who should be treated for chondral or osteochondral fragments?

Statement:
Refixation of chondral or osteochondral fragments should be the first line of treatment. In general, skeletal immaturity should not make any difference when treating chondral or osteochondral defects after FTPD but should have a lower threshold for repairing even smaller defects.

Grade: D
Rating: median 9 (range 7-9)

Literature summary:

Studies have reported that the incidence of patellar dislocation complicated with OCF, as well as the recurrence rate of instability, is high in the paediatric and adolescent age groups and represents one of the most frequent knee injuries in this cohort. The presence of an OCF, the extent of primary cartilage damage, and the number of further dislocation events significantly impact the process of early joint degeneration[1, 4, 8, 12, 14]. Additionally, the diagnosis of OCFs in paediatric patients with FTPD is more difficult and often missed, leading to a potential delay in the treatment decision process[2].

Although several reports of initial treatment strategies for FTPD with OCFs have been published[11, 15], this issue remains a debated topic. To date, none of the treatment recommendations for treating OCFs differ between skeletally mature and immature individuals. However, young patients are more susceptible to chondral-only lesions due to the lower mechanical properties of the interface between the articular cartilage and the subchondral bone[8, 9]. Although primary surgical fixation is well supported by the literature[8, 10], chondral-only full-thickness fragments are of special concern and pose a dilemma for this treatment method. On the one hand, the resultant articular defect may lead to functional limitations and eventually to early joint degeneration[1, 8, 9, 14]. On the other hand, they are more difficult to diagnose, and it is historically assumed that the fragment should have sufficient and viable subchondral bone to support successful bony integration. Therefore, traditional treatment involves the removal of loose fragments when symptomatic, followed by debridement or cartilage restoration procedures[9]. However, case reports and small series of successful healing after the repair of chondral-only injuries have been reported, indicating that the repair of these chondral-only lesions is a valuable treatment option[3, 5–7, 17]. Although most cases involve adolescents, there are also reports of successful healing in patients between 20 and 30 years of age[3, 5].

Few studies have demonstrated the successful repair of fragments in a nonacute setting. Most reports refer to children and adolescents, but there are also some reports of successful healing in adulthood. The time between the injury and the procedure varied between 3 weeks and approximately 1 year, and the clinical results were favourable[5, 13, 16]. However, the available evidence in the published literature is limited to case reports and small case series with short-term follow-up, except for a small number of studies reporting mid-term results[3, 5, 7]. In addition, reports have demonstrated unclear and inhomogeneous healing criteria.

In conclusion, skeletally immature patients should not be treated differently than skeletally mature patients in FTPD when complicated by an OCF. In young patients with an open physis, fragment refixation should be attempted if the size, integrity, cartilage status, and location of the fragment are reasonable. The same concept applies to the time between the injury and the operation. Even if early treatment makes successful healing more likely, the time interval between injury and operation seems to be less important, and fragment refixation should be attempted even in a nonacute setting if the size and integrity of the OCF allows for stable fixation.

Level of Evidence: 4

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Q22) Is there an indication for concomitant MPFL reconstruction when surgery is performed for osteochondral/chondral injuries or loose bodies in FTPD in children and adolescent patients or skeletally mature patients?

Statement:

When a chondral or osteochondral fracture has to be surgically treated, a concomitant stabilizing procedure should be used. MPFL reconstruction is the recommended procedure for addressing injured

medial structures. Skeletal immaturity should not influence this indication but may require a specific surgical technique.

Grade: C
Rating: median 9 (range 6-9)

Literature summary:

The cause of patellar instability is multifactorial, and the presence of anatomic abnormalities contributes to a greater risk of instability recurrence[22, 24]. Injury of the MPFL is of major importance since biomechanical studies have shown that the MPFL provides approximately 50% to 60% of the restraining force against lateral patellar displacement[16, 22], and Askenberger et al. reported that almost 100% of paediatric patients experienced injury to the MPFL after FTPD[3].

When surgical treatment is indicated, MPFL injury can be managed in different ways: neglected/not repaired, repaired, reconstructed during the same procedure, or reconstructed in a second-stage procedure[17]. Studies that investigated subsequent dislocations after surgery without MPFL reconstruction have shown high rates of instability recurrence. Gesslein et al.[7] reported a recurrence rate in 43% of patients who underwent surgery for OCF treatment without MPFL reconstruction. Podowitz et al.[17] showed that in 61% of children who underwent surgery for FTPD due to osteochondral fracture or a chondral loose body without MPFL reconstruction, recurrent instability occurred regardless of whether the MPFL was repaired or neglected. Several other studies have shown that MPFL repair in FTPD patients has limited value in reducing the rate of recurrence of patellar instability[10].

In contrast, in a series of 53 patients treated for a loose body after FTPD, Gurusamy et al.[8] reported that patients who simultaneously underwent MPFL reconstruction had significantly lower redislocation rates than those who underwent MPFL repair or no additional MPFL treatment (10% vs. 58.7%). Aitchison et al.[1], in a series of 40 MPFL reconstructions with osteochondral fracture fixation, reported a recurrence rate of instability in only 5% of their patients. In addition, studies that included MPFL reconstruction in the treatment of FTPD complicated by articular fragments have shown low rates of patellar redislocation[9, 18]. In addition, but outside the context of the presence of chondral or osteochondral lesions, Bitar et al.[5], in a randomized controlled clinical trial, compared nonoperative treatment and MPFL reconstruction in patients with FTPD and demonstrated that the surgical group had a recurrence rate of 0%, compared to 35% for recurrent patellar instability in the nonoperative group.

Reducing the rate of recurrence is important for several reasons. In each patellar dislocation episode, there is some degree of chondral lesion[12, 23]. Thus, recurrent instability increases the risk of developing cartilage lesions and patellofemoral osteoarthritis (PFOA) in the long-term[6]. Two retrospective studies found PFOA in 14%–29% of adolescent patients with recurrent instability after 12–14 years[2, 14]. According to Sanders et al.[19] The long-term risk of developing progressive cartilage damage and arthritis is approximately 6-fold greater in patients than in the general population. This study revealed that the cumulative incidence of PFOA was 14.8% at 20 years and 48.9% at 25 years.
In addition to lowering the rate of recurrent instability and chondral injuries, improving quality of life is important. Although not consistently reported within the literature, Nwachukwu et al.[15], in a systematic review, compared conservative and surgical treatment in children and adolescents after FTPD and concluded that surgical treatment was associated with a greater health-related quality of life and sporting function. The abovementioned study by Bitar et al.[5] reported that surgery not only resulted in a lower rate of recurrent instability but also produced better clinical outcome scores.

Considering that a high percentage of patients with recurrent instability can be successfully treated by MPFL reconstruction[11, 13], it appears meaningful to consider primary MPFL reconstruction during the initial procedure or soon after the first chondral/osteochondral surgery in a staged procedure to avoid any further redislocation or cartilage injury. On the other hand, complication rates after MPFL reconstruction have been reported to reach 26%[20], including the risk of PFOA later in life[4, 21, 26]. However, given the more widespread implementation and knowledge of MPFL reconstruction techniques and possible pitfalls, the incidence of complications seems to be decreasing[25].

In conclusion, the management of acute patellar dislocation with an intra-articular fracture and loose body is evolving. Given that the rate of recurrent instability is high after a first-time patellar dislocation and considering that several patients are not doing well with conservative treatment, there is a clear tendency to recommend primary MPFL reconstruction, particularly in patients treated primarily for chondral or osteochondral fractures.

Level of Evidence: 4

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Q23) How can malalignment and patellofemoral bony abnormalities be addressed in open physes?

Statement:
At the same time, open physes are both chance and problem (see also question 24). Guided growth to correct coronal malalignment is a method with high potential that is much easier than osteotomy in adults and should be considered when necessary. Axial malalignment can be corrected without harming the physes. Therefore, this can be carefully considered with respect to the dynamic torsion values during growth. Other bony techniques addressing the tibial tubercule or the trochlear geometry are generally not recommended for wide open physes; specific paediatric techniques can be used in selected cases. There are soft tissue options to address patella alta or a lateralized tibial tubercule if needed. Trochleoplasty can be performed safely close to skeletal maturity.

Grade: C
Rating: median 8.5 (range 5-9)

Literature summary:

Various surgical procedures that address the most common risk factors for recurrent patellar dislocation have been introduced[1, 4, 5, 8, 12, 20, 22, 23]. Most bony procedures are considered to be safe in skeletally mature patients. In skeletally immature patients, bony procedures may be contraindicated due to the open distal femoral and proximal tibial physis. Growth disturbance may occur if the physeal region is exposed to surgery (e.g., during medial patellofemoral ligament (MPFL) reconstruction) and may lead to growth arrest or malalignment[17]. However, specific surgical techniques have been described to be utilized in skeletally immature patients for whom the physis is not affected by alternative fixation methods for MPFL reconstruction[7, 15].

Several studies have shown that the MPFL is the primary constraint in preventing lateralization of the patella[3, 18]. The MPFL is a thin ligament that inserts at the proximal two-thirds of the medial border of the patella[10]. At the femur, the MPFL inserts at the bony prominence between the medial femoral epicondyle and the adductor magnus tendon[6, 10]. The femoral attachment is located at the physeal region and therefore must be noted when performing MPFL reconstruction in skeletally immature patients[9, 16, 17]. A surgical technique that avoids bone tunnel drilling at the femur is preferred, or the femoral tunnel position must be placed distal to the physis to avoid physeal disturbance[9, 19].

Among the most common bony procedures, some are contraindicated for skeletal immaturity. Trochlear dysplasia can be corrected with trochleoplasty surgery. However, trochleoplasty is generally contraindicated in skeletally immature patients, as the distal femoral epiphysis is located just under the proximal trochlea[13]. The risk of growth disturbance is, however, unknown. Surgical irritation of the anterior border of the physeal region may increase the risk of growth arrest or hyperextended distal femur abnormalities. The general opinion among patellofemoral experts is to avoid trochleoplasty when physes are widely open, but this approach can be used when patients are close to skeletal maturity[11].

The patella alta can be corrected by distalizing tibial tubercle osteotomy (TTO), and the lateralized tibial tubercle can be corrected by medializing TTO. The proximal tibial epiphysis is located at the tibial tubercle, and TTO is generally contraindicated in skeletally immature patients. To avoid growth arrest or disturbance at the tibial tubercle, alternative patellar distalizing surgical procedures have been described[14]. The patellar tendon can be imbricated to shorten it, or at a very young age, the patellar tendon tibial attachment may be changed and sutured to the tibial periosteum, not addressing the bone and avoiding the risk of growth disturbance[14].

Lower limb malalignment in the coronal plane can be corrected by hemi-epiphysiodesis, either at the distal femur or proximal tibia[15]. Guided growth corrects the valgus or varus deformity by monitoring the frontal plane alignment during the remaining growth[2] and can be considered simpler and safer than coronal plane osteotomy in adults. Significant rotational plane abnormalities, which may affect patellar stability, can be corrected in skeletally immature patients outside the physeal region, at the diaphysis of the femur or tibia[21]. However, physiological changes in the rotational plane during growth must be acknowledged.

Despite multiple options for correcting bony abnormalities in skeletally immature patients, the current literature lacks any scientific evidence on whether bony abnormalities should be addressed in FTPD and which technique should be used.

Level of Evidence: 4

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Q24) Is there an indication for growth directing procedures (e.g. hemiepiphyseodesis) in patients with open growth plates?

Statement:
The presence of valgus knees is one of the anatomical risk factors for patellar instability and can be a major risk factor for some children. Even less valgus of 3-5° in a growing child with patellar instability should be considered for correction. Alignment is part of the clinical examination and can be further visualized with radiographs and long-leg standing X-rays. When treating children, there is a possibility of minor surgery to correct the valgus deformity when there is remaining growth prior to or at the same time as the MPFL reconstruction.

Grade: D
Rating: median 8 (range 5-9)

Literature summary:

The genu valgum has been associated with patellar instability due to altered biomechanical forces on the patellofemoral joint[8]. The valgus axis increases the quadriceps (Q-) angle, and the resultant lateral force vector leads the patella to translate laterally[9]. In adults, symptomatic patellar instability in the setting of genu valgum can be effectively treated by varus-producing osteotomy, often combined with medial patellofemoral ligament (MPFL) reconstruction or other procedures[4–6].

In skeletally immature patients with open physes, the genu valgum can be corrected by growth modulation (selective hemiepiphyseodesis), where one or more physes are temporarily closed at the medial distal femur or the proximal tibia[2, 3]. Although this approach is well described and accepted for correcting primary and secondary genu valgum in paediatric patients, growth guidance to correct valgus deviation in patients with symptomatic patellar instability has rarely been reported[7, 10, 11]. For example, at a ten-year interval, Kearney and Mosca, at a university-based children's hospital, identified a total of only 22 patients with patellar instability with associated genu valgum who underwent hemiepiphyseodesis. Similarly, during a 5-year interval, only seven patients (eight knees; 10%) out of 79 skeletally immature patients who underwent MPFL reconstruction underwent a simultaneous guided growth procedure for correction of the genu valgum[10].

Clinically, mechanical alignment/genu valgum is assessed by evaluating the gross tibiofemoral angle in the stance position and by measuring the intermalleolar distance, which is indicative of valgus deviation of >8 cm. Radiographic assessment should include standing full-length radiographs of the lower extremities to calculate the tibiofemoral angle, the mechanical axis alignment zone, the anatomical (a) and mechanical (m) lateral distal femur angle (aLDFA; mLDFA), and the medial proximal tibia angle (MPTA) to identify the origin of valgus deformity. In skeletally immature patients with lateral patellar instability, radiographically based indications for surgical growth guidance included a mechanical axis line that passes through the lateral half of the knee joint characterized by aLDFA $\leq$79°, mLDFA $\leq$84°, or an MPTA >90°[7, 10, 11].

Kearney and Mosca[7] retrospectively reviewed 26 knees with patellar instability and associated genu valgum that underwent isolated selective hemiepiphyseodesis. The average age at surgery was 12.0 years (range 9.3 to 14.6), with males averaging 12.0 years and females 11.5 years. The average aLDFA significantly improved from 77.7° preoperatively (range 73.0° - 81.8°) to 84.5° postoperatively (range 79.0° - 90.0°). Of the 26 knees treated, 18 (69%) experienced complete symptom resolution, and 8 (31%) experienced a significant reduction in symptoms. However, patellar dislocation was documented in only nine of 15 patients preoperatively, and 5 of these nine patients continued to experience instability symptoms after deformity correction. Tan et al.[11] followed a series of 20 knees

(16 females and 4 males) treated with isolated hemiepiphyseodesis due to patellar instability and genu valgum. The average age of the patients was 10.3 years (range 9–12 years), and the average duration of treatment with guided growth was 16.8 months (range 12–36 months). In four patients (20%), patellar instability remained, mainly due to insufficient deformity correction (preoperative tibiofemoral angle 14.3°, postoperative tibiofemoral angle 13.1°). In a preliminary study, Parikh et al.[10] reported the results of medial patellofemoral ligament (MPFL) reconstruction and simultaneous growth modulation. Seven patients (eight knees) who underwent MPFL reconstruction and medial transphyseal screw insertion for genu valgum correction were assessed. The mean tibiofemoral angle improved from 13.1° preoperatively to 3.7° at the final follow-up, and all patients except one patient (with Down's syndrome) achieved satisfactory patellar stabilization. The authors favoured the use of transphyseal screws for temporary hemiepiphyseodesis, avoiding potential violation of the native MPFL and the MPFL graft during hardware removal[1].

The current literature considering growth guidance for patellar instability associated with genu valgum is limited to very few case series of patients with recurrent dislocations. Thus, a clear recommendation on growth modulation after FTPD can hardly be made. Nevertheless, it seems reasonable to perform selective hemiepiphyseodesis in patients whose constellation after FTPD requires primary surgical treatment and whose genu valgum is a relevant anatomical risk factor for instability. Considering the biomechanical significance of the MPFL and the persistent instability rate after isolated growth modulation in patients treated for recurrent dislocations, it seems reasonable to perform MPFL reconstruction in combination with selective hemiepiphyseodesis. The latter can be performed minimally invasively with low risk. The disadvantages of hardware removal and the risk of overcorrection or rebound phenomenon after growth guidance do not appear to be of major relevance compared to varus-producing osteotomy, which might become necessary in adulthood. However, one can argue against simultaneous surgery by performing growth modulation first and then MPFL reconstruction, if needed, once valgus deformity correction is achieved[10].

Level of evidence: 4

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Q25) What is the redislocation rate after conservative treatment of FTPD?

Statement:
The recurrence rate after conservative treatment for FTPD is at least 25%, and the percentage of patients with persistent symptoms in addition to recurrent dislocation is approximately 50%. The highest recurrence rates can be expected in children and adolescents (up to 70%).

Grade: B
Rating: median 9 (range 9-9)

Literature summary:

Conservative treatment, consisting of immobilization with a cylinder cast, posterior splint or knee brace followed by formal physiotherapy, has historically been suggested for patients with FTPD. In the literature, there is great diversity regarding both the time and method of immobilization. Typically, immobilization lasts from two to six weeks. In a retrospective multicenter study, the duration of bracing did not affect the redislocation rate, which was 27%[9]. Van Gemert et al.[6] reported that the redislocation rate ranged between 0% and 38% in patients treated with cylinder casts, between 4% and 53% in patients treated with splints, and between 6% and 54% in patients treated with braces[6]. Limitations in range of motion were greatest in the cylinder cast group and lowest in the posterior splint group. It was concluded that a posterior splint might be the best therapeutic option because of the low redislocation rate and minor knee joint restrictions. However, this recommendation is based on only one small study with significant limitations[6]. In a review article comparing different kinds of immobilization, the reported redislocation rate ranged from 17%-44%[19]. Honkonen et al., in a randomized controlled trial, compared the use of a patella-stabilizing motion-restricting knee brace versus a neoprene nonhinged knee brace for 4 weeks after FTPD. The redislocation rates were 34.4% and 37.5%, with no differences between groups, and motion restriction was associated with quadriceps muscle atrophy, decreased knee ROM, and worse functional outcomes in the first 6 months after injury[8].

A retrospective descriptive epidemiological study from the Danish National Patient Registry based upon 24,154 primary patellar dislocations showed a mean incidence of 42 per 100,000 person-years at risk[7]. Young females aged 10–17 years had the highest incidence, at 108. At the 10-year follow-up, 22.7% of the patients were at risk of experiencing recurrent dislocation, with young girls aged 10–17 years experiencing the highest risk (36.8%). Those types of registry studies might underreport true figures since they do not include those who are not in contact with the health care system. Fithian et al.[5] followed 125 patients with FTPD prospectively for 5 years and found that approximately 17% experienced a new dislocation within the follow-up period. Magnussen et al.[10] reported 111 patients who had experienced FTPD for 3.4 years, 26.9% of whom experienced a new dislocation, and an additional 51% of whom continued to have a reduced knee-related quality of life.

Several studies, systematic reviews, and meta-analyses have focused on the appropriate treatment

for FTPD by comparing conservative versus surgical treatment[2–4, 11, 14, 16–18]. In the majority of these studies, surgical treatment mainly included repair of the MPFL, either arthroscopically or in an open fashion, either at the patella or at the femoral insertion, and predisposing factors such as trochlear dysplasia, increased TT-TG, valgus or torsion malalignment were not addressed. In three studies, the redislocation rate in the conservatively treated study arm was less than 30%[1, 3, 12] and was 30%-40% in three additional studies[2, 14, 18]. No study found nonoperative treatment to be superior to operative intervention in terms of the incidence of recurrent dislocations or subsequent surgical procedures[14].

In conclusion, the redislocation rate after conservative treatment is 13%-52%[13] and might be even higher in children and adolescents, with reported rates ranging from 44% to 70%[1, 12, 15].

Level of evidence: 4

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Q26) What is the recurrence rate after surgical treatment of FTPD?

Statement:
With the correct evaluation of patients and correct surgical techniques, the outcome of surgical intervention is superior to that of conservative treatment. Some of the literature is based on data on outdated procedures such as MPFL repair or medial reefing, procedures known to demonstrate recurrence rates similar to those of conservative treatment. Few studies have focused on outcomes after MPFL reconstruction in patients with FTPD, but the current knowledge strongly indicates that the recurrence rate is lower in these patients than in those receiving conservative treatment.

Grade: C
Rating: median 9 (range 8-9)

Literature summary:

Most of the literature reporting on the recurrence rate after surgical stabilization of FTPD is based upon outdated surgical techniques such as MPFL repair or medial reefing. There are few studies reporting on MPFL reconstruction with or without combined bone procedures. Gurusamy et al.[3] reported a 10% recurrence rate after MPFL reconstruction, which was significantly better than that after either MPFL repair or continuous nonoperative treatment, with a recurrence rate of 58%.
Jiang et al.[6] investigated the clinical outcomes of MPFL reconstruction, MPFL repair and medial reefing in patients with FTPD. Their meta-analysis included twenty-two studies involving 668 patients, of which four studies involved 126 patients in the MPFL reconstruction group, ten studies involved 220 patients in the MPFL repair group, and 9 studies involved 322 patients in the medial reefing group. The redislocation rates of MPFL reconstruction, MPFL repair, and medial reefing were 1.8%, 15.4%, and 18%, respectively. There is not enough evidence to reveal that MPFL reconstruction provides better functional outcomes than MPFL repair and medial reefing.
In a review of five studies including 318 patients with results after MPFL reconstruction in FTPD, Cohen et al. [1] reported a redislocation rate of 7% and compared the results to those of a rehabilitation group including 734 patients with a redislocation rate of 30%.
In summary, it appears that nonselective medial reefing results in redislocation rates comparable to those of conservative treatment regimens. Considering individual MPFL injury patterns, selective repair of torn structures might reduce the risk of redislocation in selected patients, but MPFL reconstruction results in the lowest recurrent instability rates in FTPD patients[2, 4, 5, 7].

Level of evidence: 4

References:

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Q27) Is nonoperated FTPD a risk factor for ongoing symptoms?

Statement:

In addition to recurrent instability, a variety of symptoms, such as pain, swelling and giving way, functional and psychological limitations, and a reduction in sports participation, affect 50% of patients, reducing their quality of life. Cartilage lesions start in the first episode, and the severity of the damage correlates with the degree of persistent instability.

Grade: C
Rating: median 9 (range 5-9)

Literature summary:

Patients commonly remain symptomatic after FTPD. In addition to recurrent instability, anterior knee pain and giving way affect up to half of patients[3]. Pain is typically located anteriorly or anteromedially, and patients may report giving way episodes, clicking and catching, with symptoms worsening during flexion and kneeling[5]. Atkin et al. reported that at 6 months, 58% of patients experienced limitations in strenuous activities[3]. Although the range of motion was regained, participation in sports was reduced during the first 6 months following injury; kneeling and squatting were particularly challenging. Failure to return to sports occurred in 55% of patients, and over 50% of patients experienced complications, including patellar redislocation, subluxation, or patellofemoral pain[6].

During the early recovery phase, the most frequently reported difficulties were kneeling and squatting. At 6 and 24 weeks postinjury, 69% and 53% of patients, respectively, noted difficulties in kneeling.

Other complaints during sports activities include swelling and trouble during jumping and landing tasks. The preinjury level of sports participation was associated with age and was markedly in patients under 20 years of age. All patients showed a marked decrease in sports hours per week at 3 and 6 months compared with preinjury sports participation[5].

Many patients suffer from long-term functional limitations, even in the absence of a recurrent instability episode. Magnussen et al. reported that only 26% of patients without recurrent patellar instability after FTPD were able to return to their previous sports activities without limitations[7].

Salonen et al.[8] reported on the long-term prognosis of cartilage deterioration in 20 skeletally mature patients after conservatively treated FTPD. Initial MRI scans revealed that 70% of these patients sustained patellofemoral cartilage injury compared with 100% of patients after an average follow-up of 8 years. In addition, half of all patients presented with a grade three to four cartilage lesion during follow-up, which was not associated with subsequent instability symptoms. These findings and the results of other studies suggest that a single FTPD may initiate primary cartilage injury, leading to further gradual cartilage degeneration and PF-OA progression[2, 10].

Patellar dislocation is a significant risk factor for patellofemoral osteoarthritis, as nearly half of patients experience symptoms and radiographic changes consistent with osteoarthritis at 25 years after lateral patellar dislocation. Osteochondral injury, recurrent patellar instability, patella alta and trochlear dysplasia are associated with the development of arthritis[1, 4, 9].

Level of Evidence: 4

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Q28) What is the complication rate of surgical treatment in addition to persistent instability?

Statement:
There are no publications on specific complication rates after surgical treatment of FTPD; however, superposable complication rates of MPFL reconstructions from cohorts of heterogeneous patients with patellar instability can be expected, and the complication rate is variable. The most common complications are patellofemoral pain, reduced range of motion and patellar fracture.

Grade: B
Rating: median 9 (range 8-9)

Literature summary:

Modern approaches to patellofemoral instability yield successful results in recurrent dislocations with MPFL reconstruction, rather than repair, used as the most widely accepted surgical soft-tissue option. In a network meta-analysis of RCTs, a subgroup analysis of patients with FTPD revealed that compared with MPFL repair, MPFL reconstruction resulted in the highest P score and significantly lower redislocation rates[8]. In a review from Shah et al.[12] In 2012, the complication and failure rates of MPFL reconstruction were 26%. In a recent systematic review evaluating 28 studies with 1521 knees, the complication rate ranged from 0% to 32%, with recurrent instability between 0% and 11%. Patellar fractures occurred in 0% to 8.3% of patients. Other complications included anterior knee pain (0% to 32.3%), decreased knee range of motion (0% to 20%), chronic effusion (0% to 1.8%), and infection (0% to 4%). Reoperation rates ranged between 0% and 11%[9]. Although there are no specific data on the complication rates in surgically treated patients with FTPD, one can expect superposable rates of MPFL reconstruction in this cohort. A thorough understanding of the technical aspects of MPFL reconstruction and associated procedures will allow surgeons to avoid complications and maximize clinical outcomes[13]. Notably, Feller et al. reported that the high complication rate is based on postoperative patellofemoral pain[4]. The exact number of patients who experienced patellofemoral pain is uncertain since several studies have not included patellofemoral pain as a complication. Recent studies have suggested that MPFL reconstruction might successfully stabilize the patella, but due to residual patellofemoral pain, improvements in quality-of-life parameters that could be expected are not achieved[15]. Gorbaty et al.[6] in a follow-up after 226 isolated MPFL reconstruction found > 50% of the patients experienced pain while squatting.

MPFL reconstruction complications

MPFL reconstruction instead of repair[1, 8] is the current standard treatment for patellar instability. The treatment of choice is anatomic femoral placement using palpable osseous landmarks and fluoroscopic control, isometric confirmation with graft length analysis through range of motion and graft fixation at a degree of flexion in which the patella is engaged in the femoral trochlea (ranging from 30 to 90°) with smooth tensioning of approximately 2 N.

1) Nonanatomic femoral tunnel: The most critical technical aspect of MPFL reconstruction is anatomic femoral graft placement. Nonanatomic reconstruction results in graft anisometry associated with increased patellofemoral contact pressure and graft failure[14]. Schöttle's point, Fujino's point[5] and Stephen's percentage ratio have been reproducibly used with a true lateral radiograph of the knee. In addition, identifying osseous landmarks by palpation is a helpful tool. The apex of the adductor tubercle is a consistent landmark and is located 10.6 mm proximal to the MPFL insertion[1]. In paediatric patients, the femoral tunnel starting point for MPFL fixation is slightly distal to the femoral physis.

2) Patellar fracture: The MPFL is inserted along the proximal half of the medial patella. The fixation techniques include anchors, transpatellar sutures, suspensory devices and interference screws. The incidence of patellar fracture using two 4.5 mm long patellar tunnels is reported to be 3.6%[11]. Jackson et al. reported patellar fractures in tunnels 4.5 and 6 mm in diameter[12], whereas short, oblique patellar tunnels did not increase fracture risk[2]. Alternatively, patellar fixation may be achieved by passing the graft through two small, short oblique transosseous tunnels exiting anteromedially, avoiding fixation implants and costs and reducing the incidence of patellar fracture to 0.47%[11].

3) Excessive graft tensioning: The MPFL serves as a checkrein for lateral patellar displacement and is not under tension during normal patellofemoral alignment. The adequate tension required to re-establish native biomechanics is 2 N or 0.5 lbs[14]. Visual inspection and palpation of the graft during insertion to avoid excessive tension and to prevent the complications of anterior knee pain due to increased contact pressure are recommended.

4) Medial instability: Medial patellar instability was first described by Hughston and Deese in patients with previous arthroscopic lateral retinacular release[7]. It occurs secondary to inadequate excessive lateral retinacular release instead of lengthening and causes anterior knee pain and medial patellar instability. The diagnosis should be suspected in a patient with previous patellar realignment surgery, established by physical examination and clinical tests (taping) and confirmed by imaging techniques. This condition could almost be eliminated by avoiding overrelease of the lateral retinaculum[10].

Simultaneous correction of bony pathoanatomy in the surgical treatment of FTPD is debated in patients who present with a high degree of trochlear dysplasia, excessive patellar height, or significant torsional deformity[3]. Analysis of the inherent potential complications of these procedures is beyond the scope of this chapter but must be considered in the preoperative decision-making process.

Level of evidence: 2

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Q29) Which PROMs should be used to assess outcomes after FTPD?

Statement:
The most used PROMs are the Kujala, IKDC, KOOS and Lysholm, which are not specific for patellar instability. The Banff Patellofemoral Instability Instrument 2.0 (BPII) and Norwich Patella Instability (NPI) outcome scores are new scores developed specifically for patients (incl. adolescence) troubled by patellar instability. The BPII 2.0 has been thoroughly tested and found to be valid, reliable, and disease specific. The consensus committee recommends including the BPII 2.0 and/or NPI scores as a minimum in future studies knowing that they are not validated for all languages.

Grade: C
Rating: median 9 (range 5-9)

Literature summary:

Understanding the results of interventions for patellofemoral instability influences the treatment of this disorder, and performing quality research in this growing field requires the use of valid and reliable outcome measures[1].

In 1993, the Kujala anterior knee pain scale was introduced[3]. This score comprises a 13-item questionnaire that was developed to evaluate the subjective symptoms and functional limitations of patients with patellofemoral disorders, including anterior knee pain, patellar subluxation, and dislocation[3]. Although the Kujala score has been the most commonly used patient-reported outcome measure (PROM), the International Knee Documenting Committee (IKDC) and Lysholm scores have been found to have greater relative responsiveness than the Kujala score[6]. In addition, in a systematic review on outcome measures after patellar instability surgery, Magnuson et al.[6] reported on multiple available PROMs that have been used for the evaluation of patellar instability. The score with the highest relative efficiency was the Lysholm score; the most responsive score was the

Cincinnati knee score. Their findings highlight the great variability in the patellar instability literature, which consists of multiple PRO instruments, making comparison of results between studies challenging[6].

More recent and specific scores include the Norwich Patellar Instability (NPI) score and the Banff Patellofemoral Instability Instrument (BPII and BPII 2.0)[2, 8]. The NPI was initiated in 2013 and is a self-administered 19-item questionnaire used to assess physical symptoms in patients with patellofemoral instability. Similarly, the BPII was introduced in 2013 and was validated by the NPI and Kujala score in patients with patellofemoral instability, demonstrating a moderately strong correlation between the BPII and existing outcome measures[1]. The BPII subsequently underwent factor analysis and item reduction, resulting in the current BPII 2.0 version[4]. The BPII 2.0 is a disease-specific quality-of-life score comprising 23 questions in 5 domains, including symptoms and physical complaints; work-related concerns; sport, recreation, and competition; lifestyle; and social and emotional components. The BPII 2.0 has been found to be a valid, reliable, and disease-specific PROM that can also be used in an adolescent population[5]. Although specifically designed for patellar instability and without ceiling effects, the BPII 2.0 and NPI have rarely been used thus far[6].

Regardless of the score used, it is important to consider patient-centered outcome measures that focus on "clinical" significance from the patients' perspective. These factors may include the minimum clinically important difference (MCID), patient acceptable symptomatic state (PASS), substantial clinical benefit (SCB), and maximum improvement in outcome (MOI)[7].

Level of evidence: not applicable

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