State of the Art Review

Patellofemoral instability part 1 (When to operate and soft tissue procedures): State of the art

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ARTICLE INFO

Keywords:
Patellofemoral joint
Patellar dislocation
Operative procedures
Ligaments

ABSTRACT

Patellofemoral instability is usually initially treated non-operatively. Surgery is considered in patients with recurrent patellar dislocation and after a first-time patellar dislocation in the presence of either an associated osteochondral fracture or high risk of recurrence. Stratifying the risk of recurrence includes evaluating risk factors such as age, trochlear dysplasia, contralateral dislocation, and patellar height. Surgery with soft tissue procedures includes restoring the medial patellar restraints and balancing the lateral side of the joint. Reconstruction of the medial patellofemoral ligament is the most frequent way of addressing the medial soft tissues in patients with patellofemoral instability. Meanwhile, lateral tightness can be achieved by lateral retinaculum lengthening or release. Approaching patellofemoral instability in a patient-specific approach, combined with a shared decision-making process with the patient/family, will guide surgeons to the deliver optimal care for the patellar instability patient.

INTRODUCTION

A rapidly expanding body of literature has begun to shed light as to the best management of lateral patellofemoral (PF) instability. This is in part due to advances in imaging, improved understanding of underlying PF biomechanics as well as improved, quantifiable physical examination techniques. All of these have led to an increased focus on proper identification of the contribution of injured structures while appreciating underlying the anatomic, demographic, and social factors that may predispose a patient to a patellar dislocation and secondary risk of re-injury. Current evidence will be reviewed to provide a treatment algorithm that best guides the management of patients with a first-time PF dislocation, recurrent dislocation, and when and how-specific anatomic structures or mal-alignment issues should be addressed to prevent re-dislocation (Fig. 1). Boxes 1–6, include key articles and key points on the evaluation and treatment of patients with patellofemoral instability.

OPERATIVE VERSUS NON-OPERATIVE TREATMENT AFTER THE FIRST EPISODE OF ACUTE PATELLAR DISLOCATION

First-time (primary) lateral patellar dislocations often occur in young skeletally immature adolescents, though they may occur at any age [1–4]. These primary dislocation events are often associated with cartilage disruption [5–8] and carry an increased risk of repeat dislocation. After an acute first-time patellar dislocation, surgical intervention is recommended under certain circumstances: 1) in the presence of osteochondral fractures or loose bodies requiring internal fixation and/or fragment removal; 2) patients who are at high risk for re-dislocation; and 3) patients with persistent functional patellar instability (e.g., excessive laxity on the physical examination, unable to reach previous activity level or persistent lack of confidence in the knee) after non-operative treatment. Traditionally, all first-time dislocators that did not have a significant chondral/osteochondral injury were initially treated conservatively. 

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https://doi.org/10.1016/j.jisako.2024.05.013

Received 23 February 2024; Received in revised form 29 April 2024; Accepted 20 May 2024
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Please cite this article as: Hinckel B et al., Patellofemoral instability part 1 (When to operate and soft tissue procedures): State of the art, Journal of ISAKOS, https://doi.org/10.1016/j.jisako.2024.05.013
Should a patient fail non-operative management and re-dislocate, they then underwent surgical stabilisation of the patella. However, currently, the treatment algorithm is shifting. Failure of initial non-operative management carries significant morbidity for the patient (recurrent dislocation event, increased risk of PF chondral damage, and decreased activity) [6,9,10]. Patellar stabilisation procedures have been shown to decrease such risks through reducing the rate of re-dislocation [11].

Fig. 1. Treatment algorithm of patellofemoral instability. MPFL = medial patellofemoral ligament; MQTFL = medial quadriceps tendon femoral ligament; MPTL = medial patellotibial ligament; TTO = tibial tuberosity osteotomy.

Box 1

Key articles


Box 2

Validated outcome measures and classifications

- Banff patellofemoral instability instrument 2.0
- Norwich Patellar Instability Score
- Kujaal Anterior Knee Pain Scale
- Dejour trochlear dysplasia classification

Should a patient fail non-operative management and re-dislocate, they then underwent surgical stabilisation of the patella. However, currently, the treatment algorithm is shifting. Failure of initial non-operative management carries significant morbidity for the patient (recurrent dislocation event, increased risk of PF chondral damage, and decreased activity) [6,9,10]. Patellar stabilisation procedures have been shown to decrease such risks through reducing the rate of re-dislocation [11]. However, even patients who do not report recurrent patellar dislocations are in many cases quite limited by this injury [10].

Delay in operative treatment of patients with patellar instability can be common. Patients with patellar instability have been shown to have...
knee function affected as much as anterior cruciate ligament deficiency and be associated with more pain [12]. Still, patellar instability patients have been shown to wait on average 5 times longer for surgery (6 vs 31 months) [12]. Therefore, in the evaluation of such a patient, a systematic approach should be taken to determine the role and timing of surgical intervention to prevent future dislocation events. Risk assessments, combined with shared decision making with the patient/family is ideal as it is recognised that many patients can cope with recurrent patellar dislocations [13]. Similarly, it has been shown that surgical treatment confers greater benefits to an individual’s athletic and quality-of-life measures than with activities of daily living [11].

Several recent studies, as reviewed by Schlichte et al. [14] and Huntington et al. [15], have emerged to better define recurrence risk of a first-time dislocator. The primary risk factors of re-dislocation are younger age [16–20], skeletal immaturity [3,16,18,21], trochlear dysplasia [3,16–22], patella alta [3,16–21], increased tibial tubercle (TT)–trochlear groove (TG) distance [17,19,20,23], and bilateral patellar dislocations [17,21], whereas previously described risk factors such as female sex [16,18–20] and medial patellofemoral ligament (MPFL) injury pattern [24] were shown not to be predictive (Table 1). Furthermore, having more than one of these risk factors has been shown to have an additive effect on the overall re-dislocation rate [3,15,16,21,25,26] (Table 2). A patient who has several factors may have more than 70% risk of re-dislocation [26]. This discussion about treatment may be similar to the common conversation with an adolescent male in a contact sports that is at increased (>75%) risk of recurrence after primary glenohumeral dislocation [27,28].

Researchers from the Mayo clinic (Martin et al.) [29] developed a novel scoring system entitled the Recurrent Instability of the Patella (RIP) score. The model was developed from a cohort of operative and non-operatively managed patients with >10-year follow-up. The RIP score considers patient age (chronologic age < 25 [2 points]), their skeletal maturity (skeletal immaturity [1 point]), presence of trochlear dysplasia (Dejour classification A–D carried [1 point]), and the TT–TG to patellar length ratio (ratio >0.5 [1 point]) [15,25,27,28,30]. The score presents some intrinsic limitations, the difficulty of establishing a binary cut point for continuous variables, patellar height is not included, and the risk due to trochlear dysplasia is not graded by severity of the trochlear dysplasia; thus, the authors recommend that the score be used with caution.

When non-operative management is chosen, patients are allowed to fully weight-bear as tolerated, with gradual increases in range of motion and strengthening [29]. Knee effusions may be therapeutically aspirated in some cases at initial presentation; this can also potentially improve patellar reduction while the soft tissue stabilisers heal. Rigid immobilisations (e.g., posterior splints or plaster casts) are associated with knee stiffness and arthritis [31]. In addition, Kaewkongnok et al. demonstrated that duration of immobilisation has no effect of re-dislocation rate [32]. Therefore, brace and crutches should only be used on the acute phase to help decrease swelling and improve gait. A patellar sleeve brace can be used up to 6 weeks. Expected return to sport is between 6 and 12 weeks.

Box 3

Key issues of patient selection for surgical treatment

- Recurrent patellar dislocation
- Chondral/osteoochondral injury after a first-time patellar dislocation
- High likelihood of recurrence after a first-time patellar dislocation when two or more of the following risk factors are present (relative indication):
  - Patella alta
  - trochlear dysplasia
  - Younger patients/Skeletal immaturity
  - Contralateral dislocation
  - Increased lateral quadriceps vector

IR = internal rotation; ER = external rotation.

Box 4

Special features in the physical examination for the assessment of patellar instability

- Apprehension test
- J sign
- Hyperlaxity (Beighton score)
- Tilt test
- Patellar glide test
- Coronal alignment
- Increased femoral anteversion (Craig’s test or increased IR and decreased ER of the hip)

Box 5

Tips and tricks

- Obtain a perfect lateral view during fluoroscopy to localise properly the radiographic point for the MPFL (posterior condyles should overlap)
- Use both intraoperative fluoroscopy and anatomical landmarks (medial epicondyle and adductor tubercle) during femoral tunnel positioning to improve precision and accuracy
- Test the metrics behaviour of the MPFL (should be slight loose in flexion)
- Consider lengthening a tight lateral retinaculum (<1 quadrant of medial displacement, medial patellar tilt test < 0°)
- Allow 1–2 quadrants of patellar displacement medial and lateral to avoid excessive pressure
- Consider MPFL reconstruction in certain cases (hyperlaxity, extension subluxation, skeletal immaturity with risk factors for recurrence, flexion dislocation)

MPFL = Medial patellofemoral ligament; LRL = lateral retinaculum lengthening.

Box 6

Major pitfalls in the surgical treatment of patellofemoral instability

- Medial dislocation after a non-indicated or excessive lateral retinaculum release
- Patellar fracture associated with tunnels (higher risk in complete transosseous tunnels that violate the anterior cortex)
- Medial facet hyper pressure, arthritis or pain, secondary to malposition or overtightening the MPFL reconstruction
- Recurrence of patellar dislocation associated with technical mistakes on the MPFL-R or lack of addressing other risk factors present (patella alta, trochlear dysplasia, etc.)

MPFL = Medial patellofemoral ligament.
Table 1
Patellar redislocation risk factors and thresholds.

<table>
<thead>
<tr>
<th>Individual risk factors</th>
<th>Age</th>
<th>Sex</th>
<th>BMI</th>
<th>Skeletal maturity</th>
<th>Trochlear dysplasia</th>
<th>Patellar height</th>
<th>Increased lateral quadriceps vector</th>
<th>Patellar tilt</th>
<th>Activity level</th>
<th>Contralateral PF instability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arendt, 2018</td>
<td>–</td>
<td>ns</td>
<td>–</td>
<td>Open Physe</td>
<td>Sulcus angle ≥ 154°</td>
<td>IS ≥ 1.3</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
</tr>
<tr>
<td>Jaquith and Parikh, 2017</td>
<td>≤14 yo</td>
<td>ns</td>
<td>–</td>
<td>Open Physe</td>
<td>Dejour A-D</td>
<td>CD &gt; 1.45</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>+</td>
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<tr>
<td>Lewallen, 2015</td>
<td>&lt;25</td>
<td>ns</td>
<td>ns</td>
<td>Open or Closing physe</td>
<td>Dejour A-D</td>
<td>CD or IS &gt; 1.2</td>
<td>–</td>
<td>–</td>
<td>Sports-related injury</td>
<td>–</td>
</tr>
<tr>
<td>Huntington, 2019</td>
<td>≤14-18 yo</td>
<td>ns</td>
<td>ns</td>
<td>–</td>
<td>Dejour A-D</td>
<td>IS &gt; 1.2-1.45</td>
<td>TT-TG &gt; 14-20 mm</td>
<td>ns</td>
<td>–</td>
<td>ns</td>
</tr>
<tr>
<td>Balcrek, 2013</td>
<td>≤16 yo</td>
<td>ns</td>
<td>ns</td>
<td>–</td>
<td>Dejour A (low), B-D (high)</td>
<td>ns</td>
<td>ns</td>
<td>&gt;20°</td>
<td>ns</td>
<td>ns</td>
</tr>
<tr>
<td>Hevesi, 2019</td>
<td>&lt;25 yo</td>
<td>ns</td>
<td>Low BMI</td>
<td>Open Physe</td>
<td>Dejour A-D</td>
<td>CD ≥ 1.3</td>
<td>TT-TG/PL &gt; 0.5</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Martinez-Cano, 2021</td>
<td>&lt;21 yo</td>
<td>ns</td>
<td>ns</td>
<td>–</td>
<td>Dejour B-D</td>
<td>CD ≥ 1.15</td>
<td>–</td>
<td>–</td>
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</table>

yo = years old; BMI = body mass index; IS = Insall-Salvati; CDI = Caton–Deschamps index; PF = patellofemoral; TT–TG = tibial tuberosity–trocchlear groove distance; TT–TG/PL = tibial tuberosity–trocchlear groove distance/sagittal patellar length; ns = non-statistical difference; ‘−’ = not evaluated.

Table 2
Summary of studies reporting risk of recurrence with multiple concurrent risk factors.

<table>
<thead>
<tr>
<th>Number of risk factors</th>
<th>Risk of recurrence (%)</th>
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<tbody>
<tr>
<td></td>
<td>0</td>
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<tr>
<td>Arendt, 2018</td>
<td>7.7</td>
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<tr>
<td>Jaquith and Parikh, 2017</td>
<td>13.8</td>
</tr>
<tr>
<td>Lewallen, 2015</td>
<td>8.6</td>
</tr>
<tr>
<td>Martinez-Cano, 2021</td>
<td>31.2</td>
</tr>
</tbody>
</table>

Risk factors for Arendt, 2018 were open growth plates, sulcus angle ≥ 154°, IS > 1.3.
Risk factors for Jaquith and Parikh, 2017 were trochlear dysplasia, history of contralateral patellar dislocation, skeletal immaturity and a CDI > 1.45.
Risk factors for Lewallen, 2015 were patella alta (IS or CD > 1.2), trochlear dysplasia and chronological age < 25.
Risk factors for Martinez-Cano, 2021 were patella alta (CD > 1.15), trochlear dysplasia (Dejour types B, C, and D) and chronological age < 21. (adapted from Factors associated with increased risk of recurrence after first-time patella dislocation: A systematic review and meta-analysis., Huntington et al., AJSM2019; 1–11.doi:10.1177/0363546519888486).
IS = Insall-Salvati; CD = Caton–Deschamps index.

SURGICAL TREATMENT

Surgical treatment is indicated in the vast majority of patients with recurrent patellar dislocation, as the risk of further recurrence is elevated in these cases, in addition to the risk factors that may have been present at the time of first-time dislocation, as discussed earlier.

The ‘a la carte’ approach, developed by Dejour and Walch, as well as the ‘Lyonnaise’ team, offers individualised treatment of each knee based on anatomic abnormalities identified radiographically that may be contributing to the instability [33,34]. This approach has since evolved; with the addition of the reconstruction of the medial soft tissue restraints of the patella [35–37]. This came from the growing recognition of the importance these medial static stabilisers have on PF mechanics [38–40].

RESTORING THE MEDIAL PATELLAR RESTRAINTS

Medial retinaculum repair

If surgery is indicated in the acute setting due to the presence of an osteochondral fragment [14], MPFL repair can be considered in patients with low risk of recurrence. However, Pedowitz et al. found that children in this setting have a 61% recurrent instability rate. In particular, patients with a TT–TG distance greater than 15 mm were at the highest risk for recurrent instability. Importantly, they found that MPFL repair did not decrease the recurrence rate, although there was heterogeneity in the time to surgery in this series [41]. Askenberger et al. reported a level-1 randomised control trial that MPFL repair reduced the re-dislocation rate (22%) compared to non-operative treatment (43%) but did not improve subjective or objective knee function [42]. In addition, Puzzitiello et al. found a nearly 6 times greater recurrent dislocation rate after MPFL repair (36.9%) than MPFL reconstruction (6.3%), especially in the setting of an elevated Caton Deschamps index [43]. Nearly all of the knees that underwent MPFL reconstruction had multiple prior dislocations (96.9%), whereas roughly over half (63%) of the knees that underwent MPFL repair had multiple dislocations, strengthening the argument of reconstruction over repair in recurrent patellar instability [43]. Similar studies have shown high rates of recurrent dislocation with repair (28% [44] and 46% [45]). Thus, the authors prefer MPFL reconstruction in such cases. Given the acute nature of injury, concern for possible stiffness should be anticipated; thus consideration for a staged MPFL reconstruction can be made.

Ligament reconstruction: medial patellofemoral ligament, medial quadriceps tendon femoral ligament, and medial patellotibial ligament

The medial patellofemoral complex (MPFC) can be broken down into the proximal restraints (the medial quadriceps tendon femoral ligament [MQTFL] and MPFL) and the distal restraints (the medial patelloligament ligament [MPLFL]) [46,47] (Figs. 2 and 3). The work horse of these medial structures is the MPFL [47–51]. As such, the MPFL reconstruction has become the foundational surgical stabilisation procedure for lateral patellar instability [1,52–55].

MPFL reconstruction has demonstrated good short-term success with low recurrence rates (6.3% [43,53,55,56]) but does carry its own complications. One systematic review reported a rate of 26.1%, ranging from minor to major events [57]. Broad classifications of failures included patellar fracture, returning to the operating room to correct residual instability, findings of clinical instability on postoperative examination, loss of knee flexion, wound complications, and pain.

To avoid the catastrophic complication of patella fracture due to patellar drilling, Noyes and Albright have described an MPFL
review found only a 0.5% (3/629 patients) rate of patellar fracture associated with patellar tunnels [57]. In addition, a biomechanical study showed that risk of fracture is increased when the anterior cortex is violated [62]. Therefore, patellar fracture is not a main concern with other patellar fixations, such as anchors. However, it is important to notice that some anchor designs require the drilling of 18- to 20-mm-length tunnels potentially increasing the risk of fracture. The MQTFL reconstruction has been shown to restore native stability without increasing contact pressure [63] and to be effective in short-term clinical outcomes [59,64]. One should beware that the MPFC demonstrates the most significant length changes between 0° and 20° of flexion, whereas more isometric behaviour was seen during 20°–90°. The attachment points along the extensor mechanism demonstrate different length behaviours, where the more proximal components of the MPFC display greater anisometry through the arc of motion [65]. Anisometry of the MPFC varies not only with attachment location on the extensor mechanism but also with patellar height. Increased patellar height leads to more significant changes in anisometry in the proximal MPFC attachment point than with the distal component [66]. Therefore, when performing proximal MQTFL reconstructions, surgeons should expect increased length changes compared to reconstructions utilising distal patellar attachment sites, especially in the context of patella alta. Furthermore, many authors have begun to reconstruct both the MPFL and MQTFL ligaments simultaneously, coining the proximal MPFC reconstruction [46,67,68]. The growth of the proximal MPFC reconstruction can be attributed to a better appreciation of the discrete yet closely related functions of each medial patellar soft tissue restraint [67,69–71]. Spang et al. has reported on a single surgeon cohort (n = 25) performing a combined reconstruction with two-year follow-up. Their study has demonstrated a favourable safety profile and re-dislocation rate as compared to previously published medial retinacular plication [72] and isolated MPFL reconstruction [73].

Descending distally from the MPFC, growing evidence regarding the importance of the MPML and MPTL ligaments continues to unfold [46,47,69–71]. These ligaments have been found to be important during terminal knee extension [74,75] to counter the lateralizing quadriceps vector, as well as during deep flexion to counter lateral patellar translation [47,51]. The current body of evidence suggests these ligaments can be reconstructed as an adjunct to MPFL reconstruction. Hinckel et al. has proposed six clinical situations where augmentation of an MPFL reconstruction with an MPTL reconstruction should be performed [47,76]. These include patients with the following findings: 1) extension subluxation, 2) flexion instability, 3) skeletal immaturity with risk factors for recurrence, 4) hyperlaxity associated knee hyperextension, 5) increased Q-angle or TT–TG distance due to increased knee rotation with normal tibial tuberosity position, and 6) mild risk factors that do not warrant bony deformity correction such as tibial tuberosity osteotomy. Thus far, a systemic review [77] suggests that the reconstruction of the MPTL leads to favourable clinical outcomes and supports the role of the procedure as a valid surgical patellar stabilisation procedure, particularly when adjunct to MPFL reconstruction [47,74,76,78–81]. Fig. 4 show an MPFL plus MPTL reconstruction.

More research is needed to determine if one technique offers superior clinical outcomes to the others. Furthermore, the benefits of more anatomically multi-ligament reconstructions, and which clinical scenarios benefit the most from these adjunctive soft tissue reconstructions, have yet to be defined.

**BALANCING THE SOFT TISSUE RESTRAINTS: ADDRESSING THE LATERAL RETINACULUM**

The lateral patellar soft tissues can contribute in various mechanisms to lateral patellar instability and to medial patellar instability. These soft tissues may be excessively tight leading to lateral patellar compression syndrome, lateral patellar osteoarthritis (OA), and/or lateral patellar instability. These laterally based soft tissue patellar stabilisers include the
iliotibial band extension to patella (ITB-patella), vastus lateralis, the lateral patellofemoral ligament (LPFL), the lateral patellofibial ligament (LPTL), and the lateral patellomeniscal ligament [82–85]. Structural/biomechanical analysis suggests that the ITB-patella carries the most load of these fibres [86]. Furthermore, Cancienne et al. demonstrated in cadaveric specimens that lateral retinaculum release (LRR) results in 30% increased lateral patellar translation in full knee extension and 6–9% more translation at 10°–90° of flexion [87]. This highlights the importance of the lateral retinaculum in lateral, in addition to medial, stabilisation of the patella.

Evaluation of pathology in the lateral patellar soft tissue structures is primarily based on focussed physical exam (patellar glide test, <1 quadrant of medial displacement; medial patellar tilt test, <0°) [36,82,88] and imaging (patellar tilt >20°) [82]. It is important to be cognisant of other factors that may complicate or give rise to false-positive/false-negative testing. This may include medial restraint insufficiency leading to lateral patellar subluxation, trochlear dysplasia, or increased lateral quadriceps vector leading to increased radiographic patellar tilt but with a redundant lateral retinaculum seen on axial advance imaging [82].

In the setting of patellar instability, if the lateral retinaculum is determined to be tight and contributing to the lateral patellar instability, it may be corrected via a limited LRR, lateral retinaculum lengthening (LRL) [82], or a lateral retinaculum plasty (LRP) [89]. These procedures should not be performed in isolation for patellar instability as they do not address the underlying pathology and only serve as an adjunct to overall correction of patellar tracking. Fig. 5 shows a dissection of the lateral retinaculum in a superficial and a deep layer, similarly to what is performed in a LRL previous to placing the sutures in the desired length.

When considering between the laterally based procedures, the LRR has been associated with inferior outcomes as compared to LRL. Two prospective randomised studies have shown improved return-to-sport and functional knee outcomes after LRL compared to LRR [90,91]. Additionally, when comparing MPFL reconstruction with LRR or LRP, the LRP resulted in a greater Kujala score and less medial patellar excursion [89].

Furthermore, insufficiency of the lateral patellar soft tissue restraints may cause medial patellar instability, which is usually due to iatrogenic over release of lateral structures or hyperlaxity from collagen disorders. As with lateral patellar tightness, physical examination is key in the diagnosis as imaging may not always show abnormalities. A positive medial glide test, positive medial apprehension test [92,93], and/or positive gravity subluxation tests [94] are all suggestive of lateral insufficiency [82]. Medial subluxation may be seen in some cases on imaging in extension in isolated medial instability or in progressive flexion if combined medial/lateral instability [95,96]. If the lateral retinaculum has been determined to be insufficient, restoring its integrity is usually sufficient to restore patellar stability and improve symptoms. Options for restoring lateral patellar soft tissue tension begin with open lateral retinaculum closure. If tissue closure is not possible due to poor tissue quality/length or leads to over-tensioning of the lateral structures, a lateral retinaculum reconstruction (tissue augmentation or LPFL/LPTL reconstructions) is indicated [82,85,97–100]. Augmentation of the lateral soft tissue structures with a collagen sheet (IT band allograft or dermal allograft) is preferred to LPFL or LPTL reconstructions, given the paucity of understanding of the anatomy/biomechanics/metric behaviour of this ligaments [82].

**FUTURE PERSPECTIVES (CONCLUSION)**

PF instability is a complex pathology as it may result from numerous underlying soft tissue and bony abnormalities. Utilising a current, evidence-based approach to PF instability offers clinicians both reliable and valid...
diagnostic tools and proven treatments to best manage PF instability. Approaching PF instability in a patient-specific approach, combined with a shared decision-making process with the patient/family, will guide surgeons to the deliver optimal care for the patellar instability patient.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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