

# Patellofemoral Instability

## A Consensus Statement From the AOSSM/PFF Patellofemoral Instability Workshop

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To come to some consensus on the state of knowledge and opinion regarding the definitions of patellofemoral stability and instability, the clinical evaluation of patients with suspected patellar instability, treatment recommendations, and future directions of study on this subject, a workshop was jointly funded by the American Orthopedic Society for Sports Medicine (AOSSM) and the Patellofemoral Foundation (PFF), a nonprofit corporation with a mission to improve the care of patients with anterior knee problems through targeted research and education. Sixteen individuals with recognized expertise and experience from the fields of orthopaedic surgery, physical therapy, and basic science were invited to participate.

### METHODS

Prior to the workshop, a series of questionnaires was sent to all participants, with the goal of establishing areas of existing consensus and differences to provide focus for the workshop, which occurred on September 23, 2016, in Chicago, Illinois. During the 1-day workshop, all topics were discussed and discussions summarized. Then, a working document summarizing the day's discussion was created by the meeting chairmen (W.R.P. and D.C.F.) and sent to all the expert participants for their review and input (see list of

participants in the Appendix). All comments were carefully reviewed and incorporated into a second draft, which was sent to participants for review. At this point, all responses were blinded to the proctors, who reviewed all comments and refined the document. This draft was circulated to participants, and comments were collected and incorporated blindly for a total of 3 review cycles. By the third cycle, there were few comments, which were easily reconciled. The document was crafted into a combination of bullet points and discussion to facilitate brevity and clarity. This process was a modification of the recognized Delphi protocol to facilitate creation of consensus statements among experts.

### DEFINITIONS

We define *patellofemoral stability* as constraint by passive soft tissue tethers and chondral/bony geometry that, with muscular forces, guide the patella into the trochlear groove and keep it engaged within the trochlear groove as the knee flexes and extends.

Furthermore, we define *patellofemoral instability* as symptomatic deficiency of the aforementioned passive constraint (patholaxity) such that the patella may escape partially or completely from its asymptomatic position with respect to the femoral trochlea under the influence of displacing force. Such displacing force could be generated by muscle tension, movement, and/or externally applied forces.

*Laxity* is a physical examination finding that describes passive displacement under load.

*Patholaxity* is abnormal laxity (too tight or too loose). Further study is needed to define the line that distinguishes normal from abnormal laxity. Patholaxity can be due to genetic predisposition (as with hyperlaxity conditions) or as a result of trauma. Patellar instability is a symptom that requires patholaxity for the patella to escape partially or completely from its asymptomatic stable position. Symptomatic patellar instability happens only when there is patholaxity. Symptoms of patellofemoral instability can be episodic because even in the presence of patholaxity, neuromuscular control and articular

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congruity can maintain the physiologically adequate position of the patella and trochlear groove relative to each other.

### FACTORS CONTRIBUTING TO NORMAL PATELLOFEMORAL STABILITY

- Intact medial and lateral patellar retinaculum (soft tissue constraints)
- Articular shape of patella and trochlea
- Normal patellar height
- Normal axial and coronal skeletal alignment

### FACTORS CONTRIBUTING TO INSTABILITY

- Patholaxity of the medial and/or lateral patellar soft tissue constraints
- Decreased constraint as a result of abnormal shape of the patella and/or trochlea (trochlear dysplasia usually)
- Patella alta
- Abnormal skeletal alignment valgus and/or torsion (eg, excessive femoral anteversion, external tibial torsion, foot hyperpronation, and genu valgum)
- Deficient proximal muscular strength and control, resulting in abnormal lower extremity kinematics (excessive hip internal rotation, knee valgus, etc)

### Important Principles

- Factors causing displacement of the patella may be a combination of muscle force, insufficient articular congruency, limb alignment (dynamic and/or static), and direct trauma.
- Proximal (hip) muscle control is important to maintain control of femoral rotation; therefore, it is probably important for maintaining the trochlea under the patella.
- Hyperpronation may also contribute to internal limb rotation, exacerbating the tendency for patellar instability.
- Weightbearing muscle contraction produces a force vector that compresses the patella against the trochlea, improving stability when sufficient articular congruency exists between the patella and trochlea so that the force pushes the patella into the concavity of the trochlea. This is theoretically true, although unproven in the laboratory, and is similar to the concavity compression mechanism of stability in the shoulder.

### KEY QUESTIONS TO ASK DURING HISTORY TAKING

#### Initial Injury

- History of injury: high or low energy?
- How much swelling was present soon after the initial injury?
- Description of sensation: what did it feel like at the time of injury?
- Did you see your kneecap out of place?
- Reduction needed?
- Family history of patellar instability and/or systemic hypermobility?

#### Recurrent Injury

Same questions as for initial injury, plus the following:

- What activities have provoked recurrent symptoms?
- Response to prior treatment?
- How severe was pain and swelling this time?
- Number of episodes of instability?
- Was knee function normal between episodes (pain and/or perceived instability)?
- Review history of initial event: high or low energy?
- Age at onset?
- Bilateral?
- Pain or instability more of a problem?
- Patient/family goals and expectations?
- Family enabling or supportive?

### PHYSICAL EXAMINATION KEY POINTS

#### Patients With Suspected Acute Patellar Instability: First Time or Recurrent

- Patellar glide in extension and various degrees of early flexion (if tolerated) evaluating amount of displacement and endpoint (in response to force)
- Apprehension test at 30° if tolerated: does displacement produce an apprehension reaction? (subjective response)
- Tenderness along medial patella and/or medial patellofemoral ligaments
- Effusion (large effusion may raise suspicion of osteochondral fracture)
- Rotational alignment, including femoral anteversion, tibial torsion, and hyperpronation
- Hypermobility (Beighton score), emphasizing the presence of knee hyperextension
- Do not forget anterior cruciate ligament and medial collateral ligament examination
- Include general examination for range of motion of the ligament, meniscal pathology, referred pain, and neurologic compromise
- If patient is experiencing too much acute pain and swelling for meaningful examination, a repeat evaluation should be planned within several weeks
- Compare all with contralateral leg.

#### Patients With Suspected Recurrent Instability: Nonacute Visit Examination

- Standing alignment, gait (watching especially for valgus and rotational abnormalities)
- Single-leg stance, squat, or step-down as tolerated (screening evaluation of hip strength and core control)
- Patellar glide in extension and various degrees of flexion evaluating amount of displacement (laxity) and endpoint
- Apprehension test for lateral instability: does displacement produce an apprehension reaction and at what degree of flexion?
- J-sign with active knee extension/flexion

- Fixed lateral tracking, when patella fails to center with increasing flexion (may be difficult to confirm on physical examination alone)
- Effusion
- Rotational alignment, including prone femoral anteversion, tibial torsion, and hyperpronation
- Hypermobility (Beighton score)
- Hyperalgesia
- Include general examination for range of motion of the ligament (especially anterior cruciate ligament and medial collateral ligament), meniscal pathology, referred pain, and neurologic compromise.
- Compare all with contralateral leg.

### For Complex Situations or Patients With Previous Surgery

- Gravity subluxation test: gravity-provoked medial subluxation in lateral decubitus position<sup>3</sup>
- Medial apprehension test: displace the patella medially from the trochlea, observing for apprehension reaction<sup>2</sup>
- Relocation test: displace the patella medially, then flex the knee quickly and see if this reproduces the symptom of the patella moving from too far medially back to the trochlear groove<sup>1</sup>

## IMAGING KEY POINTS

### Initial Injury

- Radiographs: anteroposterior, true lateral, patellar axial (in  $\leq 45^\circ$  of flexion); lower flexion angle, if possible
- Magnetic resonance imaging (MRI) to rule out osteochondral injury, although it may not be necessary in all cases (eg, when history and examination establish diagnosis clearly and there is not a large effusion or radiographic evidence suggesting osteochondral injury)
- Computed tomography (CT), bone scan, and single-photon emission computed tomography (SPECT) are not often needed in initial evaluation of acute injury.

### Recurrent Instability

- Radiographic views as previously stated: need to be able to evaluate patella alta, trochlear morphology, and articular injury or arthrosis
- True lateral view, especially important to evaluate patella alta and trochlear morphology, which helps to determine further imaging (CT or MRI)
- Axial stress radiographs should be considered to document medial and lateral displacement under load.
- MRI or CT scan to evaluate patella alta, trochlear morphology, tibiofemoral rotation, and articular injury or arthrosis: CT images in progressive flexion of  $0^\circ$ ,  $15^\circ$ , and  $30^\circ$  may be helpful in identifying whether or when the patella is centered in the trochlea.
- MRI scan best done in extension: to evaluate femoral and tibial torsion with the advantage of avoiding

ionizing radiation and imaging the cartilage integrity and morphology better than CT; measurement of patella alta can be done well with Caton-Deschamps ratio and with use of patellofemoral index on MRI to understand articular overlap in extension. Note: If MRI scan is done in slight flexion, evaluation of patella alta may be affected when patellar engagement is being measured.

- Three-dimensional imaging via MRI or CT scan is helpful for understanding complexities of trochlear dysplasia when present.
- Reserve bone scan or SPECT scan for cases where there is pain or suspected focal articular overload, which needs to be clarified to direct treatment decision.
- Measurement of tibial tuberosity–trochlear groove (TT-TG) distance on CT or MRI is routinely made, but there is concern regarding reproducibility of this measurement and its uncertain clinical implications.

## CLASSIFICATION OF PATELLAR INSTABILITY

In general, classification of patellar instability is best described by direction of instability with degree of flexion, where instability is a secondary consideration.

- Lateral instability when patella escapes in early flexion  $<45^\circ$  (most common type of patellar instability)
- Lateral instability when patella escapes in flexion  $>45^\circ$  (patella displaces from the trochlea suddenly as the knee flexes and the dislocation cannot be prevented by the examiner—referred to as *obligatory dislocation in flexion*)
- Medial instability (usually iatrogenic)
- Multidirectional instability (lateral and medial)

## SURGICAL TREATMENT

Surgical treatment can be recommended after failure of nonoperative treatment, when history and physical examination findings are clearly consistent with diagnosis and examination under anesthesia of pathologic laxity in full extension and  $30^\circ$  of flexion.

- Lateral patellar instability in early flexion is the most common problem warranting surgery.
- Isolated lateral retinacular release or lengthening is not recommended to treat patellar instability.
- Medial reconstruction with or without lateral release or lengthening is indicated when there is no more than mild trochlear dysplasia and there is clear evidence on history, physical examination, and examination under anesthesia that pathologic laxity is present. Some patients with no trochlear dysplasia, no patella alta, and no systemic hypermobility may be candidates for medial repair or imbrication of the medial retinacular tissues.
- Lateral release or lengthening is indicated in addition to medial patellofemoral ligament reconstruction when there is pathologic lateral retinacular tightness. Tilt on imaging alone does not confirm lateral retinacular tightness. When manual correction of a laterally tilted patella

to neutral is not possible on physical examination, then suspect lateral tightness. Progressive tilt with knee flexion on CT scan suggests lateral retinacular tightness. Similarly, a patella that does not center in the trochlea with flexion presumably has fixed shortening of the lateral tissues that must be corrected to allow the patella to reduce fully.

- Tibial tuberosity medialization is not commonly included in surgery for instability.
- Many participants were cautious not to want to necessarily address alta surgically owing to perceived morbidity associated with distalization. Start to consider surgical correction of patella alta when Caton-Deschamps ratio is  $\geq 1.2$  and the patellotrochlear index (PTI) is  $<15\%$  to  $20\%$ . The morphology (degree of concavity and proximal extent) of the proximal trochlea is also an important consideration when understanding engagement of the patella into the proximal trochlea.
- Trochleoplasty is not often indicated. Deepening trochleoplasty is considered when all of the following are present: a J-sign, a boss or supratrochlear spur  $\geq 5$  mm, and a convex proximal trochlea. Participants may undergo trochleoplasty as part of primary or revision surgery based on these guidelines.

## DISCUSSION

### Surgical Treatment

The most common reason for surgery is lateral patellar instability in early flexion. We recognize that other types of patellar instability exist, including lateral instability in deeper flexion and iatrogenic medial instability, but treatment of these conditions was beyond the scope of this symposium.

Isolated lateral release or lengthening has inconsistent and generally poor outcomes as an isolated procedure for patellar instability and is not recommended.

Since we consider pathologic laxity of the medial retinacular constraints crucial to allow the pathologic lateral displacement present in lateral patellar instability, restoration of medial soft tissue constraint is the cornerstone of surgical treatment. The majority of our group believed that this is most predictably accomplished by a reconstruction-type procedure, although it was noted that medial imbrication has been reported to be effective in some circumstances. Reconstructive techniques using multiple graft types and fixation strategies were shown to be successful in retrospective studies. We do not advocate any specific technique, but we emphasize how important it is to accurately place the graft without tension. Surgeons should be able to define the proper location by anatomic dissection. In addition, it may be wise to confirm the femoral attachment site by fluoroscopy and by testing the length tension behavior of the proposed graft fixation sites intraoperatively. Depending on fluoroscopy alone may not be as accurate, owing to the technical difficulty of imaging intraoperatively and the variability of individual anatomy. Excessive tension or poor graft placement can produce severe complications and disability. Because of the

severity of potential complications, this type of surgery should be performed only by those experienced in patellofemoral surgery, thoroughly versed in the anatomic landmarks, and, ideally, trained in this specific procedure in a cadaveric laboratory setting and willing to take the necessary time intraoperatively to carefully confirm accurate graft placement.

Consider adding lateral retinacular lengthening or release to medial reconstruction when there is a tight lateral retinaculum diagnosed by physical examination *and* imaging. Note that not all patellae that appear to have pathologic tilt on imaging studies actually have a tight lateral retinaculum, since other factors, such as trochlear morphology and patella alta, may have a role in producing radiographic tilt.

Tibial tuberosity medialization is not commonly included in surgery for patellar instability. There is no evidence to indicate medialization as a necessary part of instability surgery, but many authors have traditionally recommended it as an à la carte option to reduce the lateral component of the quadriceps vector when the tibial tuberosity was abnormally lateral. The most commonly utilized measure of tuberosity position, the TT-TG distance, has been criticized in the literature for less-than-ideal reproducibility and not consistently taking tibiofemoral rotation into account. Other measures, such as the TT-posterior cruciate ligament measurement, attempted to provide a more consistent measurement of the tibial tuberosity position, but this measurement reflects only the tuberosity position with respect to the tibia itself and may not reflect the quadriceps vector. As a group, we remain skeptical of using any absolute measurement of tuberosity position as an indication for medialization. Having said that, the majority of the group would not consider medialization unless the TT-TG is  $>20$  mm and there is evidence of lateral patellar translation on axial imaging up to  $45^\circ$  of flexion. Some members of the group never include medialization in surgery for patellar instability. In cases of unusually severe lateral chondrosis or arthrosis associated with instability, the addition of anteromedial tuberosity transfer to medial stabilization has been used to unload the lateral patellofemoral joint. Anteriorization with medialization has a role in some patients with patellar instability when there is objective evidence of lateral overload (imaging and surgical findings).

In the literature, severe trochlear dysplasia has been consistently associated with patellar instability. When severe trochlear dysplasia is present, group members do consider deepening trochleoplasty in primary or revision surgery. Factors that contribute to the decision to perform trochleoplasty for patellar instability include the presence of a prominent J-sign on physical examination, a boss or supratrochlear spur  $\geq 5$  mm, and a convex proximal trochlea. Participants felt strongly that trochleoplasty is technically challenging with potentially severe complications and that its use should be limited to those surgeons experienced and trained in this procedure.

Although there is good basic science and clinical data for the role of trochlear morphology in patellar instability, concerns remain regarding the long-term effects on the trochlear cartilage after trochleoplasty, as well as the potential complications of this procedure.

If there are very prominent factors of trochlear dysplasia or patella alta, consideration may be given to address these factors as well as restore the medial constraint. In some cases with very proximal trochlear dysplasia and patella alta, the option of distalization to allow the patella to enter the trochlea earlier in flexion and “bypass” the dysplasia may be a treatment option, although no definitive guidelines can be given at this time.

Although historic guidelines for patellar stabilization surgery have favored addressing each dysplastic factor, presently there is no definitive evidence in the literature to allow us to say how many factors and in what order these factors should be addressed surgically; therefore, our recommendations must be clearly understood to represent expert opinion and not evidence-based treatment protocol.

Measurements of anatomic variables help to document these factors, but it is important not to become a slave to imaging measurements and a “cookbook” approach. Restoration of medial constraint is the most important surgical consideration. While it is important to always look for trochlear dysplasia, patella alta, and excessive lateralization of the tibial tuberosity as potentially complicating factors for any given patient, surgical correction of these variables is most often unnecessary for the average patient with lateral patellar instability in early flexion. Further research is therefore needed to evaluate how many “anatomic” factors must be addressed surgically in any given patient with different combinations of discernable objective anatomic pathology. In the meantime, we must, as clinicians, balance the morbidity and efficacy of our proposed treatments.

## FUTURE GOALS

### History and Physical Examination

- Quantify J-sign
- Establish and teach techniques to screen for hip and core strength and control
- Standardize physical examination techniques; study reproducibility

### Imaging

- Improve standardization of measurement of patella alta
- Consider weightbearing lateral imaging of alta

- Understand better the role of TT-TG or TT–posterior cruciate ligament in surgical decision making
- Evaluate potential for dynamic imaging studies
- Consider refining classification of trochlear dysplasia

### Rehabilitation

- Evaluate the role of movement patterns in onset and treatment of patellar instability

### Surgery

- Evaluate how many “anatomic” factors must be addressed surgically in any given patient with different combinations of discernable objective anatomic pathology
- Determine the interplay between alta and dysplasia and whether correcting alta alone can overcome some degree of dysplasia

## CONCLUSION

We recognize that this workshop consensus document represents opinions based on experience and understanding of the medical literature and basic principles of biomechanics, anatomy, and patient care. Not all conclusions have been scientifically proven. It was our goal to produce a document useful to clinicians and researchers regarding the clear understanding of what factors affect patellofemoral stability and instability and to provide useful, thoughtful insight into evaluation and treatment of patellofemoral instability.

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## APPENDIX Workshop Roster

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