55 Evaluation of Patellofemoral Knee Pain

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Patellofemoral pain syndrome (PFPS) represents one of the most common causes of knee pain affecting adolescents and adults, particularly in the physically active populations and especially in runners.

In a recent systematic review and meta-analysis [1] regarding the incidence and prevalence of patellofemoral pain, Smith [1] also found that approximately one in 10 military recruits and one in 14 adolescents were suffering from patellofemoral pain at any one time, and one in five of the general population had experienced pain within the last year. Reported annual prevalence in the general population was 22.7%, and in adolescents 28.9%. Elite athletes' reported prevalence varied from 16.7% to 29.3% (female university ballet dancers) and up to 35.7% in professional male cyclists. The pooled estimate for point prevalence in adolescents was 7.2%, and in female-only adolescent athletes was 22.7%.

PFPS has been reported to represent 16–25% of all injuries in runners [2], but Akodu and Nwakalor [3] noted that a 12-month prevalence of PFPS among amateur runners in Lagos state was 45.3% and the percentages of PFPS in males and females were 39.5% and 53.6%, respectively. PFPS was, therefore, 1.35-fold more prevalent in females than in males, slightly lower than 1.5 times the prevalence in females than males postulated by Taunton et al. [2] and lower than 2.23 times the incidence of PFPS reported at the United States Naval Academy (USNA) between females and males [4].

Anterior knee pain or PFPS remains, according to John Insall, an orthopedic "enigma" ("black hole of orthopedics"). At that time, in 1984 [5], John Insall devised a classification of patellofemoral disorders based on the presence of articular cartilage damage, which is present, variable, or absent. In the first group, Insall included chondromalacia (divided into four stages, the first three involving only the patella and the fourth stage involving the femoral trochlea), osteoarthritis (grade IV chondromalacia typical of older patients identified by roentgenographic findings of joint-space narrowing, sclerosis, and spurring and involving more frequently the lateral than the medial patellar facet associated with mirror femoral opposing surface involvement), osteochondral fractures, and osteochondritis dissecans. In the group with variable cartilage damage, he described malalignment syndromes, which include different levels of instability ranging from patella pain to patellar subluxation and dislocation as well as synovial plica. In the last group, Insall included peripatellar causes of pain including bursitis and tendinitis, overuse

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syndromes, reflex sympathetic dystrophy, and patellar abnormalities.

In 2002, Fulkerson [6] described six major anatomic sources of patellofemoral pain: subchondral bone, synovium, retinaculum, skin, muscle, and nerve. These structures may be affected by many factors, including systemic disease, but in orthopedic sports medicine, the most common reasons for anterior knee pain are overuse, patellofemoral malalignment, and trauma.

For many years, many studies that have evaluated the origin of PFPS have focused on the biomechanics of the patellofemoral joint, expressing the idea that the ethology of this clinical entity was related to abnormal patellar alignment and movement.

Several possible causes of the laterally translated position of the patella (valgus knee Q-angle, anteversion of the hip) and of incongruence between the patella and the trochlea (patellar dysplasia, patella alta, patella baja) have been considered and studied as factors leading to lateral malalignment of the patellofemoral joint, contributing to patellar instability and dislocation. Among the advocates of this mechanical model, four clinical presentations are possible:

1. Objective patellar instability with a history of at least one patellar dislocation and objective radiological abnormalities
2. Potential patellar instability; no patellar dislocation but presence of objective radiological abnormalities
3. Patellofemoral pain without dislocation and without objective radiological abnormalities
4. Patellofemoral osteoarthritis

In the 1980s and 1990s, "maltracking" due to quadriceps atrophy related to altered activation pattern of the vastus medialis obliquus (VMO) medially and of the vastus lateralis (VL) part of the quadriceps muscle laterally was believed to be a major cause of the abnormalities of patellar tracking.

More recently, a biological model has been proposed that the tissue around the patella can be loaded physiologically within a pain-free zone. The disruption of tissue homeostasis, outside this "envelope of function," leads to an overload of the patellofemoral joint and peri-patellar pain.

PFPS is therefore a multifactorial syndrome where proximal factors intrinsic to the hip and distal factors intrinsic to the foot kinematics converge together with knee patellofemoral factors (patellar kinematics, patellar tracking, patellofemoral contact-stress forces, and possible altered muscular functions) in causing pain and altered knee function.

The diagnosis of PFPS is primarily a clinical finding. As always in the medical practice, the first step in the evaluation of patellofemoral knee pain begins with a detailed and complete history of the patient's symptoms and problems. The patient must precisely delineate the symptoms, which brought him/her for medical treatment.

Is it the pain? What causes the onset of symptoms and what is the duration? Is it an acute or chronic pain? Has it been precipitated by a trauma? Does it occur in one or both knees?

Obtaining detailed answers will enable the physician to determine if the patient's symptomatology is caused by an overuse or an overload of the knee joint and if the situation represents an acute exacerbation of previously experienced chronic problems. The exact location; character and ameliorating or aggravating factors, movements, or activities (running, prolonged sitting often defined as "theater sign," squatting, ascending, or descending steps); systematic and possible association with other symptoms as swelling; and range of motion limitation and stiffness need to be completely investigated.

If the patient is suffering from instability episodes, the definition of the duration, the frequency, and the specific circumstances that lead to giving way will help differentiating true instability from inhibitory reflexes due solely to pain.

Most commonly, the patients with PFPS report pain located "behind," "underneath," or "around" the patella often without a precise localization. Patients wanting to indicate their pain-trigger area may draw with their hands a circle around the patella—the "circle sign."

Even if PFPS and patellar instability represent two clearly distinct pathological entities, it may occur that the patient with PFPS may complain of giving way, in most cases due to transient quadriceps muscle inhibition because of pain or deconditioning.

55.1 Physical Examination

Once a detailed history has been obtained with particular attention to recent changes in the patient's activities and in the intensity, duration, and resistance of exercises and training, particularly squats and lunges, a complete physical examination of the knee, including careful assessment of the patellofemoral joint, may begin to highlight all possible static and dynamic factors predisposing to PFPS.

Observation, palpation, and specific patellofemoral testing are completed in a stepwise fashion following a standardized routine, including the hip, lumbar spine, foot and ankle, and a focused neurovascular examination.

55.2 Inspection

Initial observation of the patient should be performed as they progress from standing to seated and supine positioning.

PFPS findings are quite often subtle, and the examiners' experience and ability to facilitate relaxation of the patient may have a critical role in a successful assessment.

Collado and colleagues [7] found that torsional or angular malalignment of the lower extremity has a significant influence on patellofemoral joint mechanics. There is, however, difficulty in defining normal patellofemoral alignment with respect to malalignment. Normally, the patella seats in the trochlea and during flexion moves medially reaching maximum contact pressures at 90° of knee flexion.

Patellar height, trochlear dysplasia, and pathological tibial tubercle-trochlear groove (TT-TG) distance represent the principal factors to consider in a patient with potential or objective patellar instability associated with patellofemoral pain [8].

55.3 Standing Examination

A general standing examination should be evaluated in the three basic cardinal planes.

Each plane presents peculiar aspects that should be examined to enable the clinician to obtain a thorough knee postural and structural evaluation to evaluate possible abnormalities that may be a source of PFPS symptoms [9].

In the anterior sagittal plane, static alignment is assessed with consideration of knee biomechanics with potential varus or valgus malalignment as well as femoral anteversion and tibial external rotation. This may be evidenced by the presence of "squinting patellae," a condition in which the patella appears to be pointing inward or medially when the patient is standing, generally caused by excessive femoral anteversion, and this is associated with a chronically elongated medial retinaculum and a tight lateral knee retinaculum.

In the lateral plane, it is easy to observe either genu recurvatum or a flexion contracture, while in the transverse plane, femoral and tibial rotation is best understood and appreciated. Excessive internal tibial rotation will create increased medial rotation of the patella position, while excessive femoral anteversion as well as external tibial torsion will create increased lateral rotation of the patella position.

Abnormal soft-tissue length can, in different ways, affect patellofemoral biomechanics. Tightness of quadriceps, hamstrings, and gastrocnemius muscles can alter patellofemoral contact pressures, while tightness of iliotibial band can affect patellar excursion. The lateral retinaculum, medial patellofemoral ligament, and synovium may also be responsible for augmented stresses on patellofemoral joint and contribute to anterior knee pain.

55.4 The Q-Angle

Basic clinical measurement of the alignment of the lower extremity is the Q-angle.

The Q-angle is formed by a line connecting the anterosuperior iliac spine to the center of the patella and a line connecting the center of the patella to the center of the anterior tibial tuberosity. The Q-angle represents in this way the line of action of the quadriceps force and normally measures 10–22°. Lankhorst et al. [10] performed a meta-analysis to search for factors associated with PFPS and concluded that these patients demonstrated a larger Q-angle, sulcus angle, and patellar tilt angle (weighted mean differences (WMD) 2.08, and 1.66 and 4.34, respectively); less hip abduction strength; lower knee extension peak torque; and less hip external rotation strength. The authors concluded that Q-angle alone is not a risk factor for the development of patellofemoral pain.

55.5 Dynamic Evaluation

Dynamic malalignment may exist during movement as a consequence of poor muscular control of the lower extremity segments. Dynamic patellar tracking alignment can be tested by having the patient perform a "single-leg squat and stand test," where an imbalance between the medial and the lateral structure's tension can be appreciated by a sudden medial deviation of the patella as the patella engages the femoral trochlea in the early phase of flexion, known as the shape of hockey stick "J" sign. Nunes et al. [11] reported that this test represents the best available test for eliciting anterior knee pain. Patellofemoral pain is evident in 80% of people who are positive in this test. This dynamic hip and quadriceps strength test imposes higher mechanical demands than a bilateral squat, which may induce compensatory movements such as knee valgus, because it requires an increased dynamic in all planes. Patients with decreased strength of the hip abductors and external rotators show several compensatory kinematic movements as ipsilateral trunk lean, contralateral pelvic drop, hip adduction, and knee abduction [12].

This dynamic malalignment may also be detected inviting the patient to step slowly upon and down from a 20 cm stool. This "step-down test" can be performed to assess hip and leg strength and endurance and requires good control of the patellofemoral extensor mechanism as this applies significant stress on the anterior compartment of the knee. The patient stands facing the examiner and is asked to stand on a 20 cm stool or box with leg to be tested and the other leg on the floor. Patient should stand with arms folded across chest and be instructed to squat down on one lower extremity 5–10 times consecutively, in a slow and controlled manner until the heel touches the floor at a rate of approximately 1 squat per 2 s. The presence of any abnormal movement of the patella when it engages or disengages the trochlea, any rotation of the trunk, and eventual loss of hip control must be noted.

When asking the patients to perform a single-leg squat or step-down test, patients affected with PFPS may show excessive contralateral pelvic drop, hip adduction and internal rotation, knee abduction, tibial external rotation, and hyperpronation.

Alternatively, the "J" sign may be observed in the supine or seated position, inviting the patient to extend the knee from a 90° flexed position: the abnormal path traced by the patella will be evident in the terminal phase of extension as one can observe the lateral deviation of the patella as it exits the trochlear groove.

It is also critical in the diagnostic process to check muscle strength and tropism.

It is therefore important to evaluate the quadriceps muscle, especially the VMO, both by visual inspection and direct measurement of the muscle girth compared to the contralateral side, in order to evaluate for any muscle atrophy. The measurements obtained will represent the baseline referral for future follow-ups assessing the improvements obtained by the rehabilitation program prescribed.

Patellar tracking needs to be carefully observed to determine if the patella rides centrally into the trochlea during knee flexion, and if it does not, then evaluate if the patella's restraints may be too lax or too tight.

Tight lateral structures have been implicated in subjects presenting with PFPS. In fact, it has been proposed that a tight iliotibial band (ITB) through its attachment of the lateral retinaculum into the patella could cause lateral patella tracking, patella tilt, and compression.

The ITB is a continuation of the tensor fascia lata and the gluteus maximus at the lateral aspect of the thigh. As it approaches the knee, the ITB separates into two functional components, the ilio-patellar band and the iliotibial tract (ITT), which attach to Gerdy's tubercle of the lateral tibial condyle and the lateral patella retinaculum, respectively.

To evaluate contracture and stretch of the ITB or ITT, the Ober or modified Ober tests can be used. To perform the Ober test, the patient is positioned lying on the contralateral hip with the bottom knee flexed to flatten the lower back. Then the examiner stabilizes the hip on the top and passively flexes the hip and knee to 90°; the hip is then stretched passively through abduction and extension by the examiner, who finally allows the knee to slowly drop by gravity until reaching its final angle. If the ITB is normal, the leg will adduct with the thigh dropping down slightly below the horizontal and the patient will not experience any pain; in this case, the test is called negative. If the ITB is tight, the leg will remain in the abducted position and the patient will experience lateral knee pain; in this case, the test is called positive.

Kendall et al. [13] modified the Ober test by extending the knee to 0° before the stretch.

With the knee straight and the pelvis in a neutral position, the thigh drops about 10° below the horizontal. It is suggestive of normal length. If the leg fails to drop, it indicates a tight ITB and TFL. In these tests (Ober, modified Ober), a normal ITT or distal ITB is stretched and becomes taut when the hip adducts beyond 0° and 10°, respectively.

55.6 Palpation

Once one has completed the observation phase, the patient is placed supine on a table with the knee extended as the physician begins to palpate the joint. A joint effusion may be present, although it is not common and may be related to additional intra-articular pathologies. Quadriceps tone is assessed both at rest and in isometric contraction.

Palpation must be conducted very carefully, following a systematic routine around the patella in an attempt to clearly define the exact location of the pain, and should be extended to the entire anterior region of the knee, including distal quadriceps, quadriceps tendon, and patellar tendon assessing for possible further or alternative sources of pain. The ITB must be palpated as well. The patella must be moved in all directions and especially medially and laterally in order to verify if its displacement causes pain.

55.7 Range of Motion

Passive and active range of motion of both the knee and the hip must be assessed and compared to the contralateral joint. Patients with PFPS usually present with a complete range of motion in flexion and extension of the knee. An asymptomatic crepitus during flexion-extension is nonspecific, but a possible painful crepitus may indicate a cartilage defect or a degenerative patellofemoral joint disease, involving the patellar surface, the femoral trochlea surface, or both as a kissing lesion.

55.8 Special Tests

Critical for correct diagnosis is the execution of all the clinical tests for patellar mobility and position and provocative tests for pain.

55.8.1 Patellar Mobility Testing

55.8.1.1 Patella Glide

To simplify the measurement of patella position and mobility, the patella has been divided into four equal longitudinal segments or quadrants, each representing 25% of the width of the patella.

With the knee in a resting and relaxed position, flexed at 30° over a towel roll, the physician, on the lateral side of the patient's knee, first establishes visually the site of the midline of the trochlea, then grasps the patella, translates it passively medially and laterally (medial glide and lateral glide) using both thumbs, and takes note of the extent of displacement (Fig. 55.1a and b). The lateral glide is also known as the Fairbank's sign or apprehension test. Therefore, it should be performed after the medial glide testing. The extent of displacement is described in relation to the width of the patella and expressed in quadrants that can be converted in 25%, 50%, 75%, and 100% of displacement beyond the midline of the trochlea. The patella can normally be manually displaced both medially and laterally between 25% and 50% of width of the patella. The displacement of less than one quadrant medially or laterally indicates tightness of opposite retinacular structure. The displacement of more than three quadrants is defined as hypermobility of the patella [13], indicating loose patella restraints, a finding often observed in adolescent females. Two quadrants of passive mobility are considered normal.

Additional patellar glide testing can be performed to assess superior and inferior motion.

The examination test to assess for superior patellar glide is performed at 30° of knee flexion and assesses the limitation of mobility of the inferior patellar tendon and soft-tissue structures.

The examination test to assess for inferior patellar glide is also performed at 30° of knee flexion and assesses the limitation of mobility of the quadriceps tendon and quadriceps muscles [9].

It is quite important to compare all these glide tests to the other knee to obtain a more complete and reliable evaluation.

55.8.1.2 Patellar Tilt Test

This test assesses for tightness of the lateral structures, including the iliotibial band and the lateral patellofemoral and patello-tibial ligaments. Lateral deep retinacular tightness is a condition that is very common in patients with anterior knee pain.

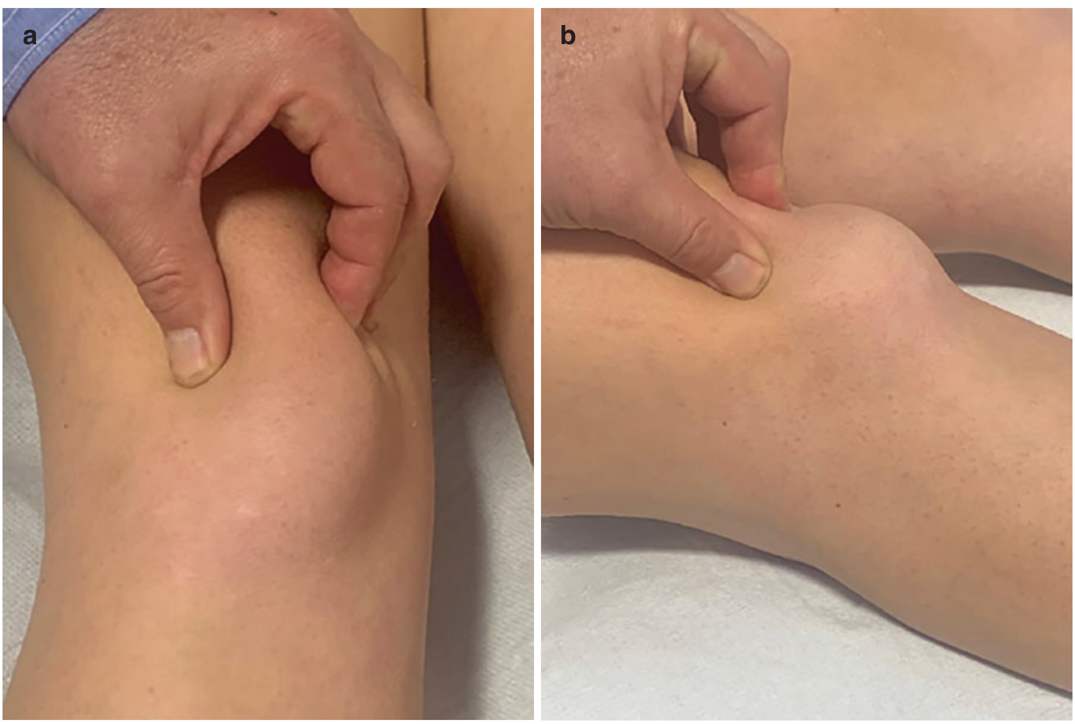

Fig. 55.1 (**a**, **b**) Patellar mobility testing. The patella is grasped between thumb and index finger in resting position (**a**) and then translated medially (**b**)

Fig. 55.2 Patellar tilt test. The patella is grasped between the thumbs and index fingers with the knee in extension, and then tilted anteriorly with the thumbs

The test is performed with the knee completely extended and the clinician standing on the lateral side of the knee to be examined. The patella is grasped between the thumb and forefinger. The medial aspect of the patella is then compressed posteriorly while the lateral aspect is elevated, trying to rotate the patella anteriorly (Fig. 55.2). If the lateral aspect of the patella is fixed and cannot be raised to at least the horizontal position (0°), the test is positive and indicates the presence of tight lateral retinaculum structures. Normally, the patella can be tilted upwards above the horizontal.

Executing comparisons with the opposite side is extremely important as wide ranges of variation of tightness are the norm.

The patella should tilt 15° with both medial and lateral tilts.

This situation can also be observed in patients with patellofemoral osteoarthritis.

55.8.1.3 Patellar Grind Test or Clarke's Patellofemoral Grind Test

While the patient is in the supine position with the knees extended, the examiner places one hand superior to the patella and displaces the patella inferiorly into the trochlear groove (Fig. 55.3). The patient is then asked to contract the quadriceps while the examiner continues to palpate the patella and provides resistance to superior movement of the patella. The test is positive if pain, crepitus, and apprehension of the patient as the irritated surfaces of the patella rub over the femur are produced, although comparison to the contralateral knee is needed to interpret the result.

55.8.2 Patellar Apprehension Test

The patient lies supine with the knee in full extension. The examiner grasps the limb at the ankle with one hand and allows the knee to be flexed over the side of the table. With the other hand, the

Fig. 55.3 Patellar grind test. The examiner's fingers displace the patella inferiorly into trochlear groove

examiner applies pressure from the medial side of the patella. As a result, the patella is forced as far laterally as possible with tension being maintained by the medial retinacular structures and medial patellofemoral ligament. The patient is asked to tighten the quadriceps muscle, and the examiner slowly flexes the knee with the other hand.

The test results positive if pain is produced.

Patient may refuse to do this test in anticipation of pain.

55.8.3 Moving Patellar Apprehension Test

The moving patellar apprehension test is performed with the patient supine with the thigh on the examining table and the clinician holding the leg in full extension off the table. The clinician then moves the patella laterally moving from an extended to a flexed position. The test is considered positive if the patient feels pain while performing this movement for lateral instability.

To confirm this test, the clinician translates the patella medially while performing the same maneuver. If the patient does not refer any symptoms on the second portion of this test, lateral instability is thought to be present.

55.9 Examination in Prone Position

The prone position enables the evaluation of the flexibility of the quadriceps.

Ely's test for rectus femoris flexibility is performed prone by placing the hip in neutral extension, a position that places the rectus femoris on stretch proximally at the hip and again distally as the knee is further flexed.

If the patient flexes the hip during this maneuver, this represents confirmation of rectus femur inflexibility or tightness.

In the prone position, it is also possible to evaluate the strength of hip extensors and hamstring muscles. Assessment of the femoral anteversion is detected by internal and external rotation of the femur with the hip in extension (Fig. 55.4a and b).

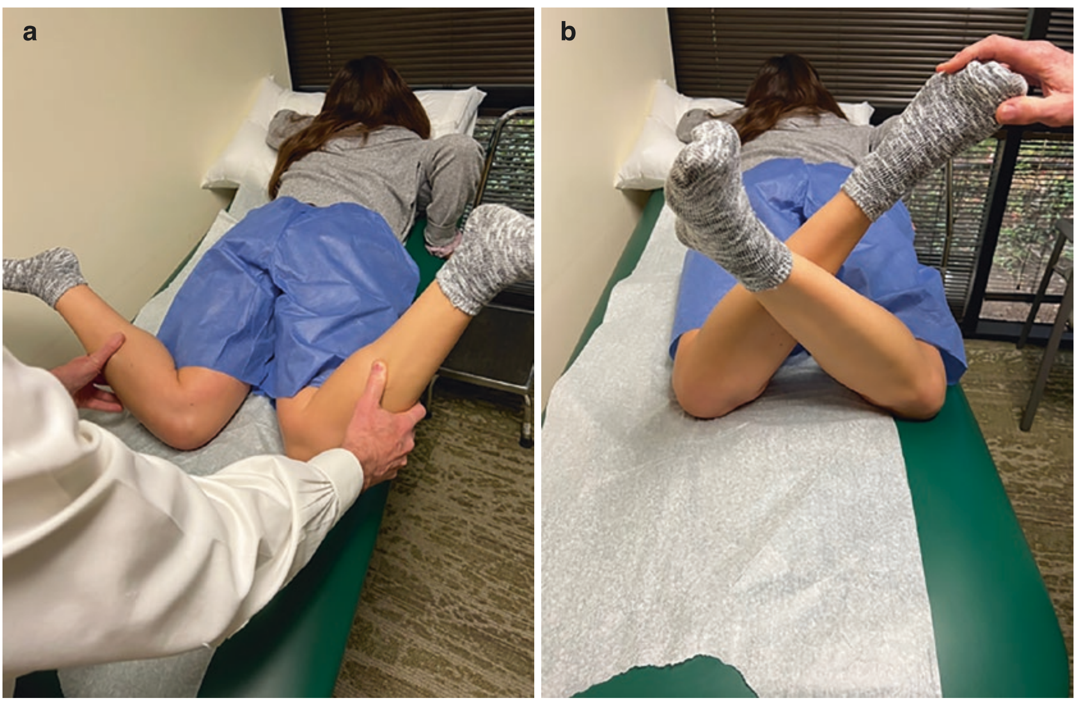

Fig. 55.4 (**a**) Assessment of femoral anteversion with external and internal rotation of the hip. (**b**) Internal rotation of the hip. (**c**) External rotation of the hip

55.10 Conclusions

The young population and the active sport population often complain of anterior knee pain due to PFPS.

Its definitive diagnosis and treatment are challenging due to the complex and multiple anatomical and functional variations, with the various bony, ligamentous, and tendinous restraints contributing to the condition.

PFPS evaluation needs a thorough history and a careful physical examination, including numerous special tests introduced over the years to define patellofemoral maltracking and instability. The clinician has therefore to be prepared and specifically informed and prepared.

Reaching the most appropriate diagnosis represents the milestone to be able to give the patient the most appropriate diagnosis and establish correct conservative or surgical treatment.

To obtain this paradigm, it is mandatory to complete the physical examination with both static and dynamic physical examination techniques. If a definitive diagnosis is not able to be determined, this should be augmented with conventional and cross-sectional imaging to assess for subtle soft tissue, bone abnormalities, or cartilage defects and lesions.

References

1. Smith BE, Selfe J, Thacker D, Hendrick P, Bateman M, Moffatt F, et al. Incidence and prevalence of patellofemoral pain: a systematic review and meta-analysis. PLoS One. 2018;13(1):e0190892. https://doi.org/10.1371/journal.pone.0190892.
2. Taunton J, Ryan M, Clement D, McKenzie D, Lloyd-Smith D, Zumb B. A retrospective case-control analysis of 2002 running injuries. Br J Sports Med. 2002;36(2):95–101.
3. Akodu AK, Nwakalor NO. Patellofemoral pain syndrome: prevalence and coping strategies of amateur runners in Lagos state. Medicina Sportiva. 2018;XIV(2):3059–67.
4. Boling M, et al. Gender differences in the incidence and prevalence of patellofemoral pain syndrome. Scand J Med Sci Sports. 2010;20(5):725–30. https://doi.org/10.1111/j.1600-0838.2009.00996.
5. Insall JN. Disorders of the patella. In: Insall JN, editor. Surgery of the knee. New York: Churchill Livingstone; 1984. p. 191.
6. Fulkerson JP. Diagnosis and Treatment of patients with patellofemoral pain. Am J Sports Med. 2002;30(3):447–56.
7. Collado H, Fredericson M. Patellofemoral pain syndrome. Clin Sports Med. 2010;29:379–98.
8. Berruto M, Ferrua P, Carimati G, Uboldi F, Gala L. Patellofemoral instability: classification and imaging. Joints. 2013;1(2):7–14. Published 2013 Oct 24.
9. Manske RC, Davies GC. Examination of the patellofemoral joint. Int J Sports Phys Ther. 2016;11(6):831–53.
10. Lankhorst NE, Bierma-Zeinstra SMA, van Middelkoop M. Factors associated with patellofemoral pain syndrome: a systematic review. Br J Sports Med. 2013;47:193–206.
11. Nunes GS, Stapait EL, Kirsten MH, de Noronha M, Sanatos GM. Clinical test for diagnosis of patellofemoral pain syndrome: systematic review with meta-analysis. Phys Ther Sport. 2013;14(1):54–9.
12. Nakagawa TH, Moriya ETU, Maciel CD, Serrao FV. Trunk, pelvis, hip, and knee kinematics, hip strength, and gluteal muscle activation during a single-leg squat in males and females with and without patellofemoral pain syndrome. J Orthop Sports Phys Ther. 2012;42(6):491–501.
13. Kendall F, McCreary E, Provance P, Rodgers M, Romani W. Muscle testing and function with posture and pain 4th edn; Modified Ober test. Philadelphia: Lippincott; 1993. p. 56–9.