# Patellofemoral Pain Syndrome: Literature Review

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***Abstract-*** Patellofemoral pain syndrome is defined as a pain in the front of the knee. This syndrome commonly happens in young athletes with prevalence rate of 33% and 18% between men and women. PFPS can be caused by malalignment of extensor lower extremity, knee and hip muscle imbalance also overuse injury during exercise. PFPS can be divided into three categories including patellofemoral instability, patellofemoral pain with malalignment and patellofemoral pain without malalignment. Diagnosis in PFPS can be obtained from history taking and physical examination, especially physical examination of lower extremities extensor. The main treatment is usually physical therapy that strengthen the extensor mechanism, patellar tapping / brace, and the use of NSAIDs, while surgery is rarely done, except in Patellofemoral Pain Syndrome which is refractory.

***Index Terms***- Anterior Knee Pain, Patellofemoral Pain syndrome, Runner's Knee.

## I. Introduction

Pain in front of the patella (anterior knee pain), has several different names, such as patellofemoral pain syndrome/PFPS, runner's knee, or jumper's knee. The incidence of anterior knee pain/patellofemoral pain syndrome is very high and occurs around 22/1000 people per year. The incidence in young women is about twice as often as men. The causes of anterior knee pain are very multifactorial, including overuse of the extensor apparatus (tendonitis, incisional tendinosis), patellar instability, condral and osteochondral damage. (Petersen & Ellerman, 2014)

## II. Definition

Patellofemoral pain syndrome (PFPS) is characterized by retro or peripatellar pain, especially during heavy load activities, such as climbing and descending stairs. Aside from pain, the clinical presentation of this syndrome can usually be in the form of muscle weakness as well as biomechanical changes in the lower limb. PFPS is the most common syndrome that can be caused by excessive use of extremities and is commonly experienced by active individuals. Physiotherapy can be done to reduce the intensity of pain and functional limitations which are associated with PFPS. Traditional treatments aim to improve patellar alignment and strengthen knee muscles. However, some studies show the influence of other joints, such as the hip. (Santos, Oliveira, & Ocarino, 2014) Several studies say that 74% of individuals who experience PFP will have limitation or stop sports activities due to excessive pain (Glaviano, Kew, & Hart, 2015)

## III. Epidemiology

PFPS is one of the most common complaint found in young adults and adolescents, especially for those who have profession as an athlete. It is reported that nearly 25% -30% of all sports medicine injuries and up to 40% of clinical visits with knee problems are associated with PFPS. The incidence of PFP is 33% and 18% of all knee injuries in each female and male athlete, respectively. This is also one of the injuries that often occur in athletes participating in soccer, volleyball and running. The incidence of young adult women is about 2-10 times more often compare to men. (Halabchi, Abolhasani & Mirshahi, 2017)

## IV. Risk Factors

PFPS risk factors can be either intrinsic or extrinsic. Extrinsic risk factors are the involvement of biomechanical factors due to the relative anatomical location of the knee, namely the proximal part (upper femur, pelvis and trunk), local (around the patella and patellofemoral joint), and distal (gastrocnemius and ankle). These risk factors can be anatomical (increased femoral anteversion, trochlear dysplasia, patella alta and steel or excessive foot pronation) and biomechanical (muscle tension or weakness), general joint laxity, gait abnormalities, and so on. (Halabchi, Abolhasani & Mirshahi, 2017)

On the other hand, intrinsic risk factors are patella and malalignment of the lower limb with muscle and soft tissue imbalance. Bone abnormalities such as dysplasia in the medial and lateral areas of the trochlear groove in the presence of asymmetrical patellar facets can reduce patellar stability and increase the risk of PFPS. Malalignment of the lower limb can also have a significant influence on patellofemoral biomechanics and increase the risk of PFPS. In PFPS there will be external weakness of pelvic rotation and abduction. (Hryvniak, Magrum, & Wilder, 2014)

## V. Classification

PFPS can be classified based on the mechanism of injury, radiographic results, biomechanics and alignment factors that contribute to dysfunction and pain. PFPS is divided into three categories including patellofemoral instability, patellofemoral pain with malalignment and patellofemoral pain without malalignment. (Hryvniak, Magrum, & Wilder, 2014) This classification system is designed to help the choose further treatment, but this classification system cannot easily apply clinically. The innovative classification system by Holmes and Clancy (Table 1) allows the classification of various pathellofemoral pathologies seen in runner injuries and clarifies PFP or instability associated with malalignment. (Collado & Fredericson, 2010)

**Tabel 1. PFPS Classification (Collado & Fredericson, 2010)**

| Classification of Patelofemoral Pain Syndrome |
|---|
| Patellofemoral Instability<br>1.Subluxation or dislocation, single episode<br>2. Subluxation or dislocation, recurrent<br>3.Chronic dislocation of patella<br>4. Associated fracture |
| Patellofemoral pain and malaignment<br>1. Increased fungtional Q-angle<br>2. Tight lateral retinaculum (lateral patellar compression syndrome)<br>3. Grossly inadequate medial stabilizers<br>4. Electrical dissociation<br>5. Patella alta<br>6. Patella baja<br>7. Dysplastic femoral trochlea |
| Patellofemoral pain without malalignment<br>1. Tight medial and lateral retinacula<br>2. Plica<br>3. Osteochondritis dissecans<br>4. Traumatic patellar chondromalacia<br>5. Fat pad syndrome<br>6. Patellofemoral osteoarthritis<br>7. Patellar tendinitis<br>8. Quadriceps tendinitis<br>9. Prepatellar bursitis<br>10. Apophysitis<br>11. Symptomatic bipartite patella<br>12. Other trauma<br>13. Reflex sympathetic dystrophy. |

## VI. 6. Mechanism/Pathology

PFPS is a diagnosis that characterized by anterior knee pain, which can be multifactorial and is caused by a combination of lower limb malalignment, muscle imbalance around the hip and knee joints, as well as overuse in sports. Each of these factors can play an important role in the development of patellofemoral pain.

### 6.1 Malalignment

Malalignment of the lower limb is a common cause of PFPS. The structural cause of PFPS can be in the form of an increase in Q angle in load-bearing activity, genu valgum, tibia varum, and patellar malalignment. This patellar stability includes complex interactions between the alignment of the femur and tibia, the osseous geometry of the patellofemoral joint, and the soft tissue resistance around the patella. Trochlear groove plays an important role in osseous stability of the patella, and trochleal hypoplasia is a common cause of congenital patellar instability. This hypoplasia often results in a cascade of pathological abnormalities including patellar malalignment, as well as causing instability or dislocation, and often kondromalacia patella. These patellofemoral malalignment factors have an important role in the pathophysiology of PFPS.

### 6.2 Muscle Imbalance

Muscle imbalance is important contributor to patellar maltracking which can cause PFPS. This imbalance includes loss of volume and strength of quadriceps muscles, especially vastus medialis obliquus (VMO). For example, quadriceps muscle tension can directly increase contact pressure between the articular surface of the femur and patella, whereas tension in harmstring and gastrocnemius can indirectly increase joint reaction patellofemoral by producing a constant flexion to the patella, while also limiting talocrural dorsiflexion, resulting in compensation of pronation in the subtalar joint and increased Q-angle dynamics. Iliotibial band tension (ITB) can also affect the normal patella, distal ITB joins with superficial fibers and deep lateral retinaculum, and affects the patellar slope and excess pressure on the lateral patella. Hypermobility also increases lateral patellar movements due to laxity in the patellofemoral medial ligament or patellomeniscal ligament, as well as association with patellar subluxation or dislocation. (Collado & Fredericson, 2010)

### 6.3 Overactivity

Overactivity is often a factor that contributes to the development of patellofemoral pain. As reviewed in epidemiological studies, the highest prevalence of patellofemoral pain is in active young patients. Rapid acceleration in activities such as athletics or military training often results in PFPS in adults. Some of the above have an important role in the complex pathophysiology of PFPS (Rothermich & Glaviano, 2015).
Pathophysiological processes such as peripatellar synovial lining and fat pad and increased in metabolic activity of the patella (similar to the initial stages of stress fracture) have been proven to be important etiologies in PFPS.

### 6.4 Theory of tissue homeostatic

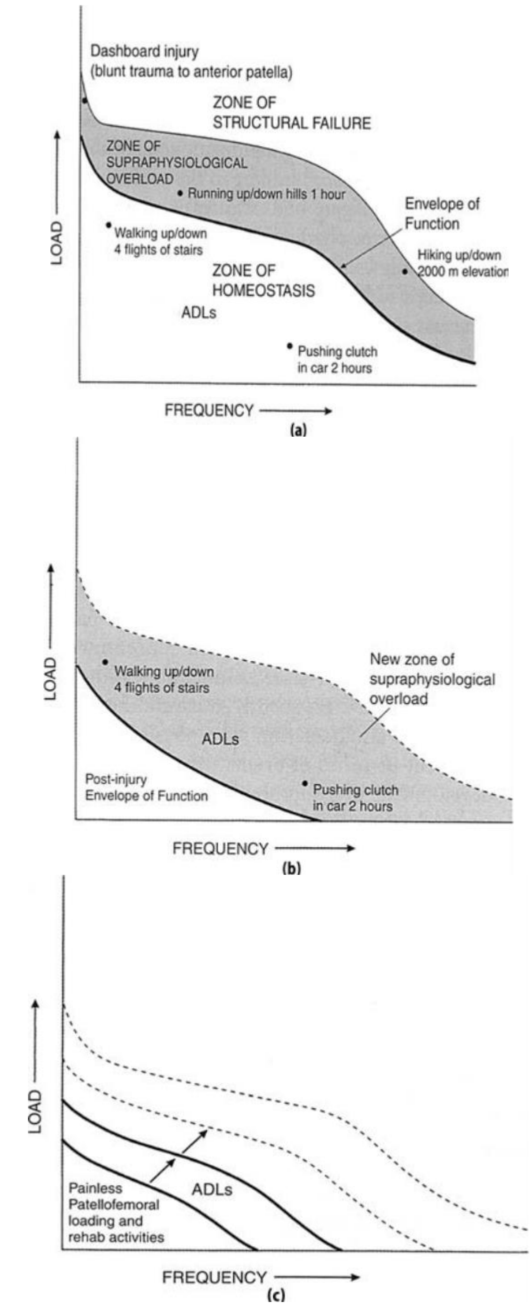
Preliminary observations on the development of the theory of homeostasis of PFPS tissue by Dye, when there were patients with complaints of anterior knee pain in the absence of chondromalacia or malalignment with an evaluation of technetium 99m methylene diphosphonate bone scan on the knee to see any other pathological abnormalities of bone. The network homeostasis theory states that the joint is more than a mechanical structure, and is an active metabolic system. This theory links pain with other physiopathological causes such as increased bone remodeling, increased intraoseous pressure, or peripatellar synovitis which causes a decrease in "Envelope of Function" (or "Envelope of Load Acceptance"). According to Dye, the Envelope of Function describes a variety of energy loading / transfer in accordance with the network system homeostasis, which is the mechanism of healing and maintaining normal tissue.

Envelope of Function in young people and athletes is bigger than inactive parents. The Envelope of Function is an area called the Homeostasis Zone. A load that exceeds the Envelope of Function but is not enough to cause a macrostructure failure is called the Supraphysiological Overload zone.

The following four factors determine the Envelope of Function or Zone Homeostasis: (1) anatomic factors (morphological, structural integrity and biomechanical characteristics of tissue); (2) kinematic factors (dynamic control of joints involving proprioceptive sensory output, cerebral and cerebellar motor sequences, spinal reflex mechanisms, muscle strength and motor control); (3) physiological factors (genetically determined by the mechanism of molecular and cellular homeostasis which determine the quality and extent of tissue repair); and (4) treatment factors (type of rehabilitation or surgery performed).

According to Dye, loss of osseous parts and soft tissue homeostasis play a role in the emergence of PFPS compared to structural characteristics. Structural factors such as chondromalacia patellae, PFM, as long as joint loading is still in the Envelope of Function, will not cause symptoms.

The Envelope of Function is often reduced after an injury episode to a level where if there are many previous daily activities that can be well tolerated (for example, going up stairs, sitting and rising from a chair) may lead to subversion of tissue healing and advanced symptoms. Reducing the loading of the Envelope of Function enables normal tissue healing. According to Dye, many patients with PFPS show quadriceps reflex inhibition caused by transient impingement of swollen, peripatellar soft tissue that is conserved such as inflammatory synovium with normal alignment. (Alfonzo, 2006).




**Picture 1. Envelope of Function Theory. (Alfonzo, 2006)**

### 6.5 Role of loading in Patellofemoral pain

Various types of activities that involve patellofemoral loading (for example, up or down stairs, squatting, kneeling, flexing) are recognized as potential factors for anterior knee pain. The patellofemoral joint is considered to be the component that is able to withstand the greatest loading on the human body, therefore it becomes one of the musculoskeletal components that does not have the ability to restore functional tissue as before in the event of injury and loss of homeostatic function. Stress experienced by the patellofemoral joint is caused by the applied load and surface area in the area of the patella and the touching femur.

Estimation of the strength of the combined reactions produced at the patellofemoral joint, under compression and tension in daily activities, are calculated based on multiples of body weight, which is estimated to be about 3.3 times body weight in activity that require walking up or down stairs, up to 7.6 times body weight in squatting, and up to 20 times body weight in jumping activity. As noted above, the actual stress on the patellofemoral joint depends on the surface area of the patella and the femur that is in contact when the load is applied. High strength can produce a burden that exceeds normal musculoskeletal capacity, produces symptomatic symptoms and pathophysiological processes that cause patellofemoral pain.

## VII. Clinical Manifestation

Patients with PFP usually have symptoms of diffuse pain in the back, under or around the patella which exacerbated by activities such as squatting, running, climbing stairs or descending stairs. If patients were asked to locate the pain, patients can place their hands above the anterior aspect of the knee or show a circular area around the patella (circle sign). Symptoms usually occur gradually, although some of them may be acute and are caused by trauma. Pain can be unilateral or bilateral and is usually described as deep and sharp pain. Occasionally, patients report stiffness or pain when sitting long with knee flexion (theater or moviegoer sign). Patients sometimes also report knee giving way or feeling locked. This perceived instability may be due to an inhibitory effect of pain on quadriceps contraction, but must be distinguished from instability in patellar dislocation, subluxation or knee ligament injury. Occasionally, there is mild swelling.

PFP is also associated with overuse, changes in sports activities, including changes in frequency, duration and intensity of exercise. Training programs should also be assessed for errors during training, including increasing the intensity of exercise too quickly, inadequate recovery time and extreme training. The use of improper footwear, sudden heavy weight training, certain activities (squats and lunges) and running on uphill surfaces. A history of trauma, including patellar subluxation or dislocation, as well as previous surgery must be recorded, because they can directly injure the articular cartilage or change the strength in the patellofemoralse area until PFP occurs. (Halabchi, Abolhasani & Mirshahi, 2017)

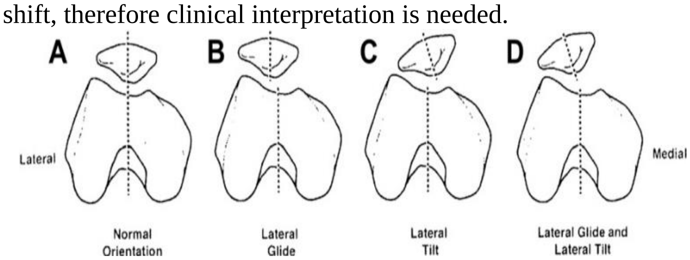
## VIII. Physical Examination

According to consensus of The Fourth International Patellofemoral Pain Research states that, anterior knee pain that appears in squatting maneuvers is the best examination on PFP with sensitivity of 80%. Palpation of patellar edge pain in PFP is evident in 71% -75% of people. Patellar grinding and inhibition tests (for example, Clarke's test) have low sensitivity and limited diagnostic accuracy for PFP. In another prospective study of diagnostic values on five general tests, the authors report three vastus tests of medial coordination, patellar apprehension and eccentric steps to have a positive ratio. (Halabchi, Abolhasani & Mirshahi, 2017)

### 8.1 Supine Examination

The difference in leg length can be seen by measuring the distance from the anterior superior iliac spine to the highest point of the medial malleolus. A leg length discrepancy of more than 1.0 cm can have side effects on the lower extremities when running. The knee joint is then observed and palpated to see if there is any swelling. At least 20 to 30 mL of fluid in the knee joint can inhibit VMO function. The examination then focuses on palpation of the patella and pain of the peripatellar tissue. The lateral retinaculum is joined by vastus lateral and ITB, and pain that is often palpable in this area is associated with chronic and recurrent stress from malalignment of the patella. Ventral or dorsal patellar tendon pain is associated with patellar bursitis and tendinopathy, whereas pain on the patellar tendon side is associated with inflammation of the fat pad Hoffa.

Grelsamer and McConnell described 4 components that were believed to affect the static or dynamic position of the patellar: glide, tilt, rotation, and anterior-posterior. The glide test is an assessment of the lateral/medial shift of the patella, and measures the distance from the patellar midpole to the medial and lateral femoral epicondyle with knee flexion up to 200. The glide component is examined using a measuring tape to record the distance from the midpatella to the lateral femoral epicondyle and the distance from the midpatella to the midpatella to the knee medial femoral epicondyle. The midpatella point is determined by visual assessment. A lateral displacement of the 5 mm patella causes 50% reduction in tension in the vastus oblique medialis. In PFPS patients, it is usually very natural to experience a lateral shift, therefore clinical interpretation is needed.

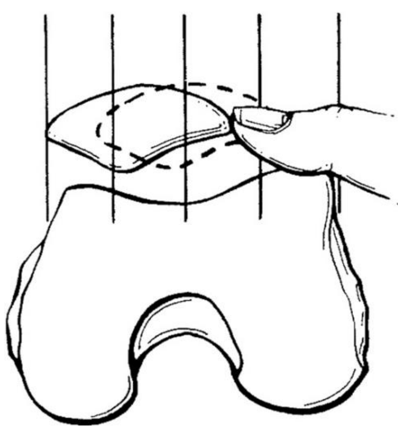



**Picture 2. Patella orientation with Lateral Glide and tilt components**

The patellar slope compares the height of the anterior aspect at the medial patellar border with the height of the anterior aspect to the lateral patellar border. This slope is considered normal when two level limits in the frontal plane. In mild slopes, more than 50% of the depth of the lateral border can be palpated but the posterior surface is not palpable; and in slopes less than 50% of the depth of the lateral border can be palpated. To determine the dynamic slope, active and passive contractions are simulated to move the patella medially. If the lateral tilt is very severe, this can cause lateral patellar compression syndrome, and requires surgical management.

Measurement of the rotation angle also helps to determine the deviation of the long axis of the patella on the long axis of the femur, and is believed to be another indication that certain parts of the retinaculum become tense and are a potential source of symptoms. In normal rotation, the line connecting the superior and inferior poles of the patella is parallel to the long axis of the femur. If the inferior pole is medial to the long axis of the femur, this indicates internal rotation; if the inferior pole of the patella is lateral to the long axis of the femur, this signifies external rotation. Anteroposterior alignment (A-P) evaluation is to assess whether the inferior pole is tilted posteriorly compared to the superior pole. Tilt can irritate the fat pad and is common in patients who experience pain in the extension or hyperextension of the knee, because the inferior pole is located on the fat pad. These patients are often diagnosed with patellar tendonitis, and usually experience pain with a quadriceps examination and a leg lift. A-P slope occurs when the distal third of the patella, or inferior patellar pole, cannot be palpated as a third superior and superior pole. The anterior-posterior dynamic slope can be determined during maximal quadriceps contraction. If the inferior pole disappears and forms a hollow, then the test is positive.

In the assessment of patellar mobility, this test is performed with knee flexion of 20o to 30o with relaxed quadriceps. This test is done by resting the patient's knee on the examiner's thigh or with a small pillow under the patient's knee. The patella is divided into 4 longitudinal quadrants, and the patella is moved medially and laterally with the thumb and index finger of the examiner to determine patellar shift. Lateral displacement of 3 quadrants indicates restraint in the medial section. Lateral quadrant displacement 4 defines the presence of patellar dislocation. The medial shift from only one quadrant indicates the presence of a tense lateral retinaculum and is usually correlated with an abnormal passive patellar tilt test. There is an association between patellar hypomobility and ITB. Medial shifts in quadrants 3 or 4 show the presence of patellar hypermobility without lateral resistance, and are often seen in generalized lateral ligament laxity. Hypermobility with lateral patellar glide is correlated with laxity in the patellofemoral or patellomeniscal medial ligament and patellar subluxation. When the test is positive, it is specific to patellar instability. Stability of the ligaments in both knees is also checked, especially if there is a history of previous knee trauma. Anterior and posterior cruciate ligament deficiency is also associated with peripatellar pain. The range of motion of the pelvis, the femoral acetabular impingement test, and the faber maneuver must be performed to check for pathological presence in the knee to the articular pelvis.



**Picture 3. Medial and Lateral Patellar Mobility Assessment**

**8.1.1 Medialis Vastus Coordination Test**

In the supine patient's position, the examiner places a fist under the knee of the subject and asks the patient to extent the knee slowly without pressing or lifting away from the examiner's fist. Patients are instructed to achieve full extension. The test is considered positive when there is a lack of coordination on full extension, so the patient cannot do the extension using hip extensors or flexors. A positive test may be an indicator of vastus medialis obliquus muscle dysfunction.

**Picture 4. Vastus Medialis Coordination Test**

**8.1.2 Patella apprehension test**

The patella apprehension test, also called the Fairbanks Apprehension test, is done with the patient in the supine and relaxed position. The examiner uses one hand to push the patient's patella as lateral as possible, in order to obtain a lateral patellar glide. Starting with knee flexion at 30°, the examiner grasps the patient's foot at the ankle/heel, combining flexion on the knee and pelvis. This lateral glide is maintained during this test. The test is considered positive when pain occurs.

**Picture 5. Patellar Apprehension Test**

**8.1.3 Waldron test (First and Second Phase)**

To perform the Phase I Waldron test, the patient lies on his back and the examiner presses the patella toward the temporary fatigue while performing passive knee flexion with the other hand (Figure a). For Phase II, the patient stands to do a full squat, and the examination slowly compresses the patella towards the femur (figure b). In both phases, crepitation and pain during certain parts of the range of motion are considered pathological signs of PFPS.


**Picture 6. Waldron's Test (A) Phase 1, (B) Phase 2**

**8.1.4 Clarke Test (or Grinding Patellofemoral test)**

The Clarke test is performed with the patient lying supine with both knees held by a pad, to form knee flexion (10°-20°) and patellofemoral articulation in the patellofemoral joint. While the patient is relaxed, the examiner presses the distal patella (with the hand on the superior patella) and then asks the patient to contract the quadriceps muscle. If the patient's pain occurs during the test, the test will be considered positive. However, as explained earlier, the Clarke Test is not recommended as a diagnostic test for PFPS because of the lack of understanding of the underlying mechanism.

**Picture 7. Clarke's Test**

**8.2 Standing Examination**

**8.2.1 Alignment statis**

Alignment of pelvic anatomy and lower extremities has a role in the occurrence of PFPS, and is called a 'static alignment' because this examination can be done when the patient is not moving. Alignment of the lower limb is evaluated by the presence of femoral anteversion; knee position (genu varum, valgum, or recurvatum); external tibial rotation; and alignment weight bearing legs and ankles. The clinical measurement of lower limb alignment is the Q-angle. The Q-angle is formed by a line connecting the anterior superior iliac spine to the center of the patella to the anterior tibial tuberosity. This angle is considered to draw a line on the force that occurs in quadriceps. Some studies found that an angle greater than 160 was a risk factor for PFPS

**8.2.2 Dynamic alignment**

Dynamic malalignment can occur due to poor muscle control in the lower extremity segment. The examination can be done by doing single leg squats. Poor dynamic alignment can be seen when the clinician observes a consistent pattern when the patient performs a single leg squat or step down resulting in excessive contralateral pelvic drop; pelvic adduction and internal rotation; knee abduction and external tibial rotation and hyperpronation. When an MRI is carried out with a weight bearing, it has been proven that internal femoral rotation usually occurs in PFPS. This concept also contributes to femoral weakness in PFPS, as well as pelvic abductors and external rotators. Weakness of the gluteus medius can produce contralateral pelvis. Weakness in medical gluteus causes the contralateral pelvis to fall, and places the stance leg in the adduction position, accompanied by excessive internal rotation of the femur and tibia, and hyperpronation of the subtalar joint. Immediate lateral movement of the patella, accompanied by a full extension knee can be categorized as abnormal, which is called a positive J-sign, this movement is due to excessive lateral force when the patella moves to the femoral trolea when flexing 10º and 30º, this is found in some people with patellofemoral instability. (Collado & Fredericson, 2010)

**8.2.3 *Eccentric step test***

For the eccentric step test, the patient does not use footwear. Steps as high as 15 cm or more is accurate, height is equivalent to 50% of the length of the tibia. The patient stands on the board, hands on the hips and slowly steps down. The patient must keep a hand on the pelvis during this test. After the patient does a test with 1 foot, and is repeated with the other leg. Previous warm-up or practice on this test is not permitted, this test is considered positive if there is pain during the test.

**Picture 8.** *Eccentric Step Test*

**8.2.4 *Standard step-down test***

The standard step-down test is similar to the eccentric step test, except that the patient must stand with his hands folded on his chest and squats 5-10 times in a row slowly, until the heels touch the floor, maintaining their balance with one squat per 2 seconds. Scoring of deviations in the trunk, pelvis, hips and knees indicates the time of onset of anterior gluteus medius, torsion of abduction of the hip, and decreased lateral trunk force.

**Picture 9. Standard Step Down Test**

**8.2.5 *Lateral step-down test***

Lateral step down test is a modification of the standard step down test, where the movement is in the lateral direction. The instructions for the lateral step down test are as follows: Patients are asked to stand on one foot 15 cm apart. Then the knee is bent about 60° during the examination, the patient is then asked to bend and touch the opposite leg, then return to the starting position. During this test, we can be assessed several things, such as arm strength to maintain balance, body alignment, pelvic plane (pelvis plane), knee posture and balance.

**8.2.6 *Single Leg Squat***

Single-leg squats are dynamic checks on the hips and quadriceps. This maneuver requires higher mechanical strength than bilateral squats, which require compensation such as valgus on the knee. This may be partly due to smaller restraints and an increase in the amount of dynamic control needed in all fields during single leg squats. Compared with controls, PFPS patients showed increased ipsilateral body resistance, falling contralateral pelvis, hip adduction and knee abduction during one leg squatting. As noted earlier, the general intrinsic risk assessment of the PFPS factor is very important in physical examinations as well as for planning appropriate rehabilitation programs.

**Picture 10.** Single Leg Squat

**8.3 Sitting Examination**

In a seated position, the height of the patella can be assessed. Prominent infrapatellar fat pad often accompanies the patella alta, as does the genus recurvatum. Patella alta is more commonly seen in women and is a common finding in congenital subluxation of the patella, as it causes the patella to enter the femoral sulcus while flexing the knee. Patella baja is less common and can be seen as a complication of anterior cruciate ligament reconstruction. When the tibia tubercle is located more lateral than normal, therefore the patellar tendon becomes a slightly lower at a certain angle rather than directly downward, in addition there is also a torsion of the proximal external tibial. Dynamic patella tracking is a measure of patellar instability. During this evaluation, the examiner asks the patient who is seated to actively for knee extension from 900 to full extension, and observes the pattern of patellar movement from the front. In most individuals, the patella appears to move proximally straight, with a slight lateral shift near the terminal extension (J-sign). The term J-sign describes the path of the patella with maltracking. Instead of moving superiorly with knee extension, the patella also deviates laterally on the terminal extension as it exits the trochlear groove, to make an inverted J-shaped path. (Collado & Fredericson, 2010)

**8.4 Side Lying examination**

In a side-lying position, with knees bent at 20$^{o}$, the lateral retinaculum can be evaluated for excessive tightness by passively moving the patella medially. To test the inner fibers, the hands are placed in the middle of the patella, and anteroposterior pressure at the medial border of the patella is applied. The lateral border of the patella should move freely from the femur, and the palpation of tension in the retinacular fibers should be similar. In this position the rigor of ITB can be evaluated by the Ober test, and gluteus medius can be tested if there is a strength deficit.

**8.5 Examination with Pronation Position**

This position allows a more accurate assessment of ligament of the front and rear legs, subtalar position, gastroc-soleus, and quadriceps muscle length.

**8.6 Observasional Gait Analysis**

Observational gait analysis is one of the most important aspects of checking, evaluating dynamic functions by observing the runner's angle when walking and running. It has been found that shocks with excessive impact during the heel strike phase and the propulsion phase while running can increase the risk of PFP. (Halabchi, Abolhasani & Mirshahi, 2017)

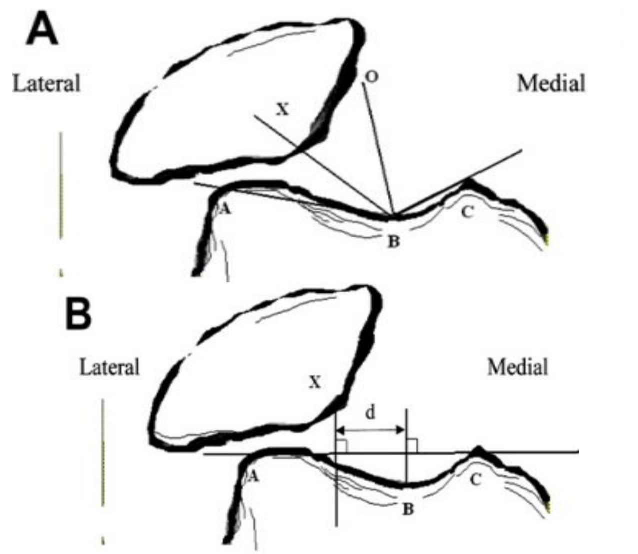
## IX. Investigation (Imaging)

The diagnosis of PFPS mainly depends on the patient's history. Radiography is an adjunct to clinical evaluation and physical examination. It is important to get radiographs on runners with a history of PFPS and no improvement after several weeks of conservative treatment, or if there is a history of trauma or dislocation that has just occurred. Sometimes radiographic findings do not correlate well with clinical complaints and it is often difficult to distinguish between injuries and normal finding. When imaging is indicated, plain knee radiograph (A-P, lateral weight-bearing, and axial) is useful for eliminating other causes of anterior knee pain, including bipartite patella, osteoarthritis, and loose bodies. On standard knee A-P radiographs, one can identify accessory center ossification, degenerative joint disease, and other unrelated conditions, such as bone tumors. Lateral view is very helpful for assessing the height of the patella. Several techniques are used to measure the distance between the tibia plateau to the inferior pole, which must be equivalent to the length on the surface of the articular patella. The normal range is 1.0, if higher indicates patella alta. This view can also help evaluate the presence of degenerative changes in the patellofemoral joint, osteocondritis in patellar distress, patellar morphology, trochlear groove dysplasia and central accessory ossification and ectopic calcification of the retinaculum. The position and orientation of the patella towards the trochlear groove can also be evaluated by sulcus angle, congruent angle, and patellar tilt angle. The angle of the sulcus can be measured with the angle on the trochlear bone. With the knee flexed at an angle of 35º-45º, while the normal sulcus angle is around 145º. Patellar instability is associated with depth in the trochlear, where if the trochlear is getting steeper it can be associated with patellar pain without instability.

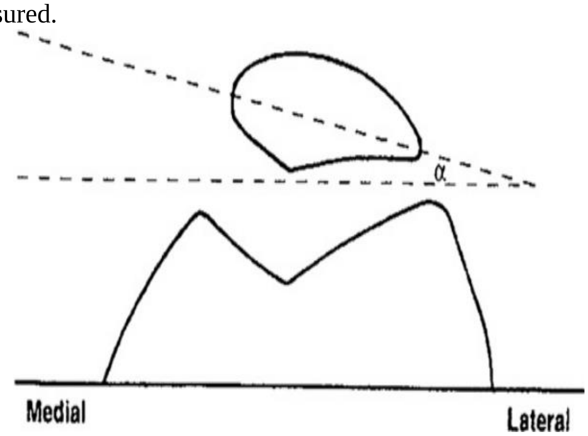
Congruent angles defined as index of medial/lateral subluxation of the patella in the trochlear groove, almost the same as the physical examination assessment on the patellar glide, and in normal joints, the average angle is 6º (standard deviation 11º). The new axial linear displacement measurement can be a simple alternative method for evaluating the position of the patella relative to the trochlear groove similar to the congruence of angular measurements. The patellar tilt angle is an index of the medial/lateral tilt of the patellar plane relative to the femur. In the normal patellofemoral joint, the angle formed by the lateral patellar facet and each horizontal line must be open laterally, where patients with subluxation of the patella, the lines used to determine the angle are parallel or medially open. For this evaluation to be accurate and repeatable, radiographs must be taken with vertical legs and the film disk is kept parallel to the ground surface. Slope angles between 0º and 5º are normal, 5º to 10º are thresholds, and angles greater than 10º are considered abnormal.

If surgery is to be performed and a plain photo examination results are negative, MRI or computed tomography (CT) scan should be used to further evaluate the existence of patellar tracking. Serial CT scans taken at knee flexion angles in the range of 0º to 30º can provide greater information regarding patellar tracking in trochlear grooves. Measurements of sulcus angles, congruent angles, and patellar tilt angles can be done on CT scan and may help to determine the cause of patellofemoral pain. Three malalignment patterns can be characterized by congruent angles and patellar tilt angles: lateral subluxation without lateral tilt, subluxation with slope, and slope without subluxation

Kinematic studies can also be done with MRI without radiation exposure. In addition to defining the patellofemoral abnormality, MRI can also assist in assessing degenerative joint changes, such as cartilage fissure or thinning, subchondral edema of the bone marrow, subchondral cysts, and other pathological entities such as synovial plica and patellar tendinitis.




**Picture 11.** A) BO Congruent Corner Lines are ABC bisector angle lines. The BX path passes through the lowest point on the medial edge of the patella. The OBX angle is the fit angle. If the BX line falls to the medial side of the BO line, the angle is expressed as a negative degree. If it falls to the lateral side of the BO line, it is expressed as a positive degree. (B) the reference line is drawn by connecting the most lateral anterior aspects (A) and medial (C) troklear facets. The line is drawn perpendicularly from the depth of the sulcus (B) through the line reference (AC). Another line is drawn perpendicular to the posterior aspect of the patellar spine (X) through the reference line. To get the measurement distance from the lateral, (d) 2 intersections are measured.




**Picture 12.** Patellar tilt angle. The slope of the angle is measured by the line joining the patella angle to the horizontal line (Halabchi, Abolhasani, & Mirshahi, 2017)

## X. Management

### 10.1 Operative Management

For most patients with patellofemoral pain, surgical intervention is usually not indicated. Surgery can be considered when a patient is refractory to non-operative management for 6 to 12 months. Interventions must be carried out according to appropriate indications, including abnormalities that can be specifically handled by surgery. Surgical management includes patellar realignment, resurfacing, and arthroplasty. Lateral Release Realignment is a proximal realignment procedure that is most appropriate for patients with lateral retinaculum tightness and lateral patella tilt. This procedure is minimally invasive, using arthroscopy or combined with an open approach. Pain and instability due to medial patellar subluxation are serious complications, often arising after aggressive surgery. Some patients may require a realignment procedure, including proximal imbrication or medial patellofemoral ligament reconstruction. The initial movement of the knee is very important to avoid stiffness after surgery. Tibia osteotomy is also used as a distal realignment procedure and is most appropriate for patients with lateral malalignment accompanied by lateral and distal patellar facets. Patients with patellofemoral pain are often successfully treated with medial tibia tubercle transfer. Anteromedial transfer is another type of surgery and is an option that can reduce the patellar burden and reduce postoperative stiffness. Full-weight bearings must be avoided for 6 weeks to allow healing after osteotomy. Distal realignment procedures are generally contraindicated for proximal and medial patellar facet lesions. Cartilage restoration resurfacing procedures, including autologous chondrocyte implantation (ACI-C) and osteochondral transfer, have had success in a population of patients with patellofemoral pain caused by defects in the cartellofemoral joint cartilage.

The final surgical options include patellofemoral arthroplasty, which is indicated in the case of late stage osteoarthritis degeneration, and may allow a return to sports activities with some limitations. The effectiveness of surgical interventions for patellofemoral pain remains difficult to assess, because most of the available researches are a series of uncontrolled cases. Another surgical option that arises is patellofemoral troploplasty to treat patients with patellofemoral dysplasia by deepening the trochlear duct. This procedure has shown good short-term results for patients with dysplasia. However, little evidence is available to support long-term success.

### 10.2 Non operative Management

Although many patients with patellofemoral pain can improve with surgical management, non-operative care remains a mainstay for initial management of the problem. The spectrum of non-operative management options includes a variety of treatment modalities. Patellar tapping, bracing, pharmacology, and the use of therapeutic ultrasound are non-operative treatment options that are controversial in the literature and have not been universally accepted.

#### 10.2.1 Rehabilitation

PFPS management must include a comprehensive rehabilitation program. Symptom control (activity modification, nonsteroidal anti-inflammatory drugs, ice packs, patellar tapping, or brace) is the first stage, then the patient can be classified by the mechanism that is thought to cause the pain: abnormal patellofemoral joint mechanism, changes in alignment or movement in the lower extremities, and overuse

**a. Strengthening Quadriceps Muscle**

Strength restoration and quadriceps function have been shown to be a significant contributing factor in reducing the patellofemoral symptoms. During open chain training, the quadriceps muscle strength required by the knee for extension will increase as the knee moves from 90$^o$ to full extension. In addition, contact area of the patellofemoral joint will be reduced when the knee is extended, thereby increasing joint stress. Conversely, during closed chain exercises, strength in the quadriceps muscles will be minimal when the knee is extended, therefore stress is reduced. This exercise includes: lunges, wall slides, and leg press machines. Both open chain and closed strengthening exercises must be carried out so that reinforcement can be done throughout the range of motion. Isometric and kinetic open chain exercises, such as knee extension, are recommended if there is a significant quadriceps weakness or pain during weight bearing. As soon as possible, patients can do core exercises during a rehabilitation program that includes a quadriceps strengthening regimen with closed kinetic chains, which is more effective than isokinetic and open chain exercises.

To improve quadriceps eccentric control, rehabilitation programs include exercises performed while standing on one leg. In this position, the lower abdominal and gluteal muscles work together to maintain pelvic level, simulating the activity of the stance gait phase. Activation of the lower abdomen and oblique muscles helps to reduce anterior rotation of the pelvis therefore produce internal rotation of the femur.

***b. Patellar Tapping***

Correcting abnormal patellar posture using the Grelsamer and McConnell tapping technique is one of the way to optimize the entry of the patella in the trochlea, and this transition step in rehabilitation process is for patient who is unable to do strengthening exercises due to pain. Tapping the patella in individuals with symptoms during exercise up and down the stairs can reduce symptoms by up to 50%. In addition, increase in quadriceps activity can help increase loading in the knee joint.

***c. Patellar Brace***

Patients with patellar pain report reduced pain from properly using dynamic patellar brace stabilization. Powers et al found that 50% of subjects experienced improvement in symptoms with the use of patella brace stabilization. Further studies showed no effectiveness was found on the use of patellar braces on patellar tracking as measured by MRI kinematics. (Halabchi, Abolhasani & Mirshahi, 2017)

#### 10.2.2 Neuromuscular Electrical Stimulation

This treatment method is electrically induced muscle contraction and can be used to complete or replace voluntary contractions during physical therapy. This modality shows an increase in the electrical capacity of VMO patients who have undergone neuromuscular electrical stimulation. However, its use in isolation has not been proven to exceed the efficacy of formal physical therapy programs. This therapy is not widely accepted as a substitute for physical therapy and remains a controversial complement to physical therapy in the treatment of patellofemoral pain patients. (Rothermich & Glaviano, 2015)

## XI. Conclusion

Patellofemoral pain syndrome characterized by a collection of clinical symptoms of anterior knee pain with multifactorial causes, in the form of a combination of malalignment of the lower limb, muscle imbalance around the hip joint and knee, as well as overuse in sports, without any pathological abnormalities in the patellofemoral cartilage. PFPS is characterized by pronation in the subtalar joint, thereby increasing Q-angle.

Another theory states there is an imbalance in network homeostasis, which causes macrostructure failure. Network homeostasis throughout the system is described as "Envelope of Function", this can be influenced by several external factors. Symptoms are usually diffuse pain in the area around the patella, and there is a feeling of locking (knee giving way) in the knee. PFPS can also be detected through physical examination, such as anterior knee pain that appears when patient squat (squatting maneuver).

Non-operative treatment of PFPS remains the main management choice, this can be in the form of tapping, bracing, pharmacological, and the use of therapeutic ultrasound.

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