Patellofemoral pain syndrome in female athletes: A review of diagnoses, etiology and treatment options

Patellofemoral pain syndrome in female athletes: A review of diagnoses, etiology and treatment options

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Abstract

Patellofemoral pain syndrome (PFPS) is one of the most common causes of knee pain and is present in females disproportionately more relative to males. PFPS causes tend to be multifactorial in nature and are described in this review. From a review of the current literature, it is clear that there needs to be further research on PFPS in order to better understand the complex etiology of this disorder in both males and females. It is known that females with patellofemoral pain syndrome demonstrate a decrease in abduction, external rotation and extension strength of the affected side compared with healthy patients. Conservative management, including optimizing muscle balance between the vastus medialis and lateralis around the patella along with formal therapy should be the first line of treatment in patients presenting with PFPS. Surgery should be reserved for patients in which all conservative management options have failed. This review aims to guide physicians in accurate clinical-decision making regarding conservative and surgical treatment options when specifically faced with PFPS in a female athlete. Furthermore, we will discuss the anatomic variants, incidence and prevalence, etiology, diagnosis and treatment of PFPS.

Introduction

Patellofemoral pain syndrome (PFPS) is the most common cause of knee pain in female athletes and is a result of imbalances in the forces controlling patellar tracking during knee flexion and extension (Table 1).[1] Symptoms include pain behind or around the patella that is increased with running or other knee flexion activities, such as squatting and walking up and down stairs. PFPS is disproportionately present in females relative to males.[2] The goal of this review is to guide physicians in making accurate clinical decisions when evaluating PFPS in a female athlete.

Knee anatomy and patellofemoral pain syndrome

The patellofemoral joint consists of the patella, the distal and anterior aspects of the femur as well as the articular surfaces and surrounding supporting structures.[3-5] The patella is the largest sesamoid bone in the body and is of a relatively constant length, width and thickness.[6,7] Seventy-five percent of the posterior aspect of the patella is covered by cartilage up to five millimeters thick. This cartilage has both elastic and viscous properties. The fluid component allows for force absorption and lubrication of the articular surface, while the elastic portion helps to distribute and absorb forces.[8-10] The tendons of the four components of the quadriceps muscle converge in the distal portion of the thigh and unite to form a single broad quadriceps tendon. The patellar tendon, which inserts on the tibial tuberosity is the continuation of this quadriceps tendon in which the patella is embedded. The medial and lateral vasti muscles of the quadriceps also attach independently to the patella and form aponeuroses, known as the medial and lateral patellar retinacula, respectively.[7,11]

PFPS is the name given to a variety of pathologies that lead to anterior knee pain. PFPS is difficult to define because patients experience a variety of symptoms and may have different levels of pain and physical impairment.[8,12] Further, most current literature focuses on studies performed with male participants, limiting the knowledge of treatment options for females with PFPS.

Incidence and prevalence

PFPS is the most prevalent orthopedic condition seen in sports medicine and is a common presenting complaint in adolescents and young adults.[13,14] PFPS is also the primary diagnosis in about 25% of all running injuries.[5,15] Treatment for PFPS is especially promising for the short term, but long-term results are much less successful.[16] The total incidence for PFPS ranges from 8.75% to 17%; however, the incidence among females is much greater at 12.7% compared to 1.1% of males.[17] Young females who regularly participate in running and jumping activities may be particularly at risk.[2] In a clinical analysis of 40 women with PFPS, pain was associated with increased activity. Chronic overloading and overuse of the patellofemoral joint, rather than malalignment, can also contribute to patellofemoral pain.[18] A study of freshmen at the United States Naval Academy conducted by Boling *et al.*[19] found that females were 2.23 times more likely to develop PFPS compared with males. Additionally, Boling et al found that the prevalence of PFPS was not significantly different between sexes at the time of admission to the US Naval Academy. This data

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along with other studies suggests that females are more affected than males by a rapid increase in physical activity level, which in turn leads to a higher incidence of PFPS.[19,20]

Etiology

The causes of PFPS in females are multifactorial and include overuse injuries of the extensor apparatus (tendonitis or insertional tendinosis), patellar instability, chondral and osteochondral damage.[21]

Malalignment of the lower extremity

Malalignment of the lower extremity has been cited as a potential contributory factor in the development of PFPS. Femoral neck anteversion, genu valgum, knee hyperextension, Q angle, tibia varum and excessive rearfoot pronation are some of the alignment factors that have been associated with PFPS.[8]

Q angle is defined as the angle between the line connecting the anterior superior iliac spine to the center of the patella and the extension of a line from the center of the patella to the tibial tubercle.[21] A greater lateralization angle is exerted on the patella with a greater Q angle, which increases the load on the lateral facet of the patella and the lateral femoral condyle. A 10% increase in the Q angle will result in increased stress to the patellofemoral joint by 45%.[22] A Q-angle greater than 20 degrees for women is considered clinically abnormal.[23] While some data suggests that a greater Q angle is not a risk factor for PFPS, others suggest that a high Q angle may be a contributing factor in maintaining PFPS once it has been acquired.[24] Additionally, some authors have attributed excessive dynamic knee valgus malalignment in patients with PFPS compared to normal patients.[25]

Patterns of patellar malalignment include subluxation with and without patellar tilt as well as patellar tilt without subluxation.[8] In a computerized tomography study of the patellofemoral joint during active flexion and extension, lateral patellar translation and tilt was present in 8 out of 20 knees with anterior knee pain.[26] Abnormal surface tracking at the patellofemoral joint has often been cited as a potential cause of PFPS.[27] Patellar tracking, which targets dynamic patellofemoral alignment throughout knee range of motion, is essential for healthy joint function and affects contact and load transmission.[28] Cartilage thickness also has been suggested to influence joint contact and as a result may be another contributing factor to PFPS.[29,30] Furthermore, in patients with trochlear dysplasia and patellofemoral instability, Shin *et al*.[31] reported decreased trochlear volume and length compared to normal control groups. Thus, normal patellofemoral tracking is dependent on many factors.

Although dynamic lateral patella maltracking is a risk factor for PFPS, static patellar malalignment can also be a contributing factor.[32] Differential action of the quadriceps, in particular the vastus medialis obliquus, has been involved in the etiology of PFPS.[33] Lin *et al*.[32] observed that vastus medialis obliquus activation in PFPS patients caused greater medial patellar rotation than in healthy subjects. Additionally, they reported that the three-dimensional kinematic action of the vastus medialis obliquus is actively modulated with knee flexion angle in healthy subjects, but that this modulation was not present in PFPS patients. These results could be attributed to differential vastus medialis obliquus insertion on the patella or medial quadriceps weakness.

Muscular imbalances

Decreased strength due to atrophy or inhibition of the lower extremity musculature has been suggested as a possible cause for PFPS.[8] There are a number of muscular imbalances that are thought to contribute to PFPS development and include decreased knee extensor strength, weakness in eccentric muscle strength, imbalance between the vastus medialis obliquus and vastus lateralis components of the quadriceps, and hip muscle weakness.[34] Studies have shown that quadriceps atrophy is associated with PFPS pain syndrome.[35-37] However, Thijs *et al*.[34] observed that the strength of hip muscle groups in female runners who developed patellofemoral pain did not significantly differ from those of the asymptomatic runners.[34] Other more recent studies suggest that female athletes with greater hip abduction strength might be at an increased risk of developing PFPS.[38]

Decreased knee extensor strength: quadriceps volume and strength deficiency

Decreased knee extensor strength is a common finding in patients with PFPS.[8] Thomee *et al*.[8] found that patients with PFPS have more symptoms and pain during the last thirty degrees of maximal sitting extension. A study on young women with PFPS showed significantly lower knee extensor strength in the symptomatic knee. Further, the patients had less vertical jumping ability and were weaker, with the largest differences in eccentric knee extension. Affected patients had lower strength, EMG activity and significant differences in muscle activity between the vastus medialis and rectus femoris muscle. Another feature of PFPS is decreased knee extensor torque. Kaya *et al*.[39] showed that women with PFPS have a decreased torque, total volume, and cross sectional area of the quadriceps muscle. Decreased torque also leads to muscular imbalances that increases the risk of PFPS.

Lephart *et al.*[40] indicated that females have significantly more hip internal rotation to maximum angular displacement, and less lower leg internal rotation time to maximum angular displacement compared to males. Females also have significantly less peak torque to body mass for the quadriceps and hamstrings than males. Weaker thigh musculature could be associated with stiffening of the knee and lower leg upon landing in females.[9] Additionally, Besier *et al.*[41] reported that PFPS patients had greater contraction of quadriceps as well as hamstrings and greater normalized muscle forces during walking, although the net knee moment was similar between PFPS patients and healthy pain-free controls. Females displayed 30-50% greater normalized gastrocnemius and hamstring muscle forces during both running and walking when compared to males.

Vastus medialis obliquus insufficiency and atrophy

Vastus medialis obliquus imbalance relative to the vastus lateralis has been cited as one of the main contributors to abnormal patellar tracking.[34] Under normal conditions, the vastus medialis obliquus and vastus lateralis counteract each other and are considered to be important patellofemoral joint stabilizers.[42] When the balance of the vastus medialis obliquus and vastus lateralis is disrupted, it is often attributed to insufficiency of the vastus medialis obliquus due to atrophy, hypoplasia, inhibition or impaired motor control.[43] Hence it has been suggested that PFPS is linked to a decrease in vastus medialis obliquus muscle mass.[34,44] The insertion of the vastus medialis obliquus is along the medial border of the patella and it extends from one third to one half of the way down from the proximal pole. Jan *et al*.[45] found that insertion level of the vastus medialis obliquus was significantly higher in patients with PFPS than healthy controls. Further the vastus medialis obliquus fiber angle was significantly smaller than in healthy control knees.

Differential activation of vastus medialis obliquus *versus* vastus lateralis

Another theory regarding the etiology of PFPS suggests that there is a differential activation time between vastus medialis obliquus and vastus lateralis. Poor coordination of activation onset times of vastus lateralis and vastus medialis obliquus can lead to abnormal patella tracking.[46] Akkurt *et al*.[47] reported a significant delay in the activation onset time of vastus medialis obliquus in the affected knee of female patients at fifteen, thirty and forty-five degree knee extension angles as measured by electromyographic recording. They also reported that the delay in female patients was more pronounced at knee angles closer to full extension. Conversely, Karst *et al*.[48] found no difference in the initial activation of vastus medialis obliquus and vastus lateralis activities in patients with PFPS and asymptomatic individuals during three testing conditions: reflex knee extension, active knee extension in non-weight bearing and weight bearing situations. In a systematic review and meta-analysis of the literature, Chester *et al*.[49] evaluated 14 studies comparing the timing of EMG onset of VMO and VL in patients with PFPS versus asymptomatic individuals and found considerable heterogeneity between each study design. Although the data indicate a trend towards a delay in the VMO activation relative to VL in the PFPS patient population during both the voluntary task and reflex activities, the authors could not draw a clinical or therapeutic significance due to the variability in physiological function among normal individuals.

Hip muscle weakness

While hip muscle weakness is not directly associated with the patellofemoral joint, it is often associated with PFPS. The kinetic chain theory states that dysfunction of a joint can manifest injuries in other joints, most usually those distal to the affected joint.[34] It has been demonstrated that during running, females exhibit significantly greater external knee valgus movement and hip internal rotation than males.[40] The ability to control and prevent these motions relies on the strength of the proximal muscle groups that are antagonistic to these movements. If there is not sufficient proximal strength, the femur may adduct or internally rotate, which in turn increases lateral patellar contact pressure which may lead to pain.[50] Ireland *et al*.[50] reported that female PFPS patients had 26% less hip abduction strength and 36% less hip external rotation strength. Other similar studies conducted in a sample of females reported results that were in agreement with this study.[51,52]

Gluteal muscle activation

It has been shown that altered hip joint kinematics is demonstrated in patients with PFPS. Females with PFPS have demonstrated increased hip internal rotation during single step downs, running and jumping.[53] Increased hip adduction and knee abduction during walking have also been observed in female patients with PFPS. These transverse and frontal plane rotations are thought to reduce patellofemoral contact area and increase patellofemoral joint stress, which leads to pain. It has been proposed that altered neuromuscular control of the musculature that resists hip adduction and internal rotation may contribute to the kinematic differences observed between females with PFPS and healthy controls.[53]

Overuse

Although many studies have attempted to explain the etiology of PFPS, most have focused on muscular imbalances and biomechanical abnormalities. However, physical activity level and overuse is also an important factor in the development of PFPS.[8] Fairbank *et al*.[54] reported that female patients with PFPS were more involved in competitive sports than age-matched controls and that pain was related to increases in physical activity level. In fact, Thomee *et al*.[18] found that all female patients who reported symptoms of an insidious onset of PFPS had been involved in temporary overuse or a period of increased physical activity. Interestingly, females with a high physical activity level did not report more pain than those with a lower activity level.[18] This suggests that a drastic increase or change in activity is the stimulus leading to PFPS development rather than a consistently high level of activity.

Clinical evaluation

Females (62% of cases) are at a significantly greater risk of experiencing patellofemoral pain syndrome than males (38% of cases).[55] Anatomic, hormonal factors and knee laxity, and neuromuscular factors contribute to the higher risk, with anatomic factors being the most commonly discussed.[56,57] One of the neuromuscular factors lacking in females is hip muscle strength.[58] Further, females have less hip external rotation and abduction strength than men. Female athletes who suffered a lower extremity injury during the season had a significant deficit in hip abduction and external rotation strength compared to injured controls.[59] Excessive femoral adduction and internal rotation may increase the dynamic quadriceps angle and lead to greater lateral patellar contact pressure.[28] In order to evaluate PFPS, the clinician must first evaluate the lower extremity alignment and the extensor mechanism.[20] The clinician should aim to distinguish between an alignment problem within the patellofemoral joint, an alignment issue outside of the patellofemoral joint or absence of malalignment.[20] Within the so called miserable malalignment syndrome, a CT Scan is necessary to diagnose torsion, rotation and femoral neck anteversion correctly.[60,61] The first step is visual inspection of the lower extremity with the feet together. Full-length alignment radiographs is essential for the accurate diagnosis and measurement of malalignment to guide management.

The source of pain in PFPS may not always be malalignment or patella instability, but instead excessive loading of the patellofemoral joint. The excessive loading may be a consequence of a single event or may be chronic in nature.[62] In the majority of PFPS patients, no abnormal anatomical or biomechanical reasons for the symptoms exist.[20] Both a static and dynamic evaluation of the entire leg should be performed. The patient should stand and walk barefoot while the alignment and functionality of the lower extremity is evaluated. If there is a functional abnormality, the clinician should determine the reason for this compensatory mechanism, such as muscle weakness, muscle tightness or patellar hypermobility. The clinician should also evaluate for discrepancies in leg length and intrinsic foot imbalances. If an intrinsic foot imbalance exists, orthotics may be included as part of an effective treatment program.[63] If malalignment of the lower extremity is observed, mobilizing techniques and a formal exercise and stretching program can be used to correct postural and movement dysfunction.[20] Additionally, the clinician can incorporate 5 functional performance tests which include anteromedial lunge, step-down, single-leg press, bilateral squat, balance and reach to further assess patient progress.[64]

The patella should be evaluated for glide, medial and lateral tilt, anterior and posterior tilt, and rotation. Exam findings should be compared to the contralateral normal side as some patients have excessive laxity but without any pain. Examination using radiographs, in particular the sunrise view to evaluate patella tilt and CT should be used for further evaluation of patellar tracking. MRI should be utilized to rule out meniscal, ligamentous or cartilage pathology. The condition of the non-muscular tissue around the patellofemoral joint must also be examined. The medio-lateral displacement test allows the clinician to reliably test the mobility of the patella and to determine whether it is normal, hypermobile or hypomobile. Previous studies show a possible link between the role of the menstrual phase and hormonal factors in the development of PFPS. An increase in knee laxity and other ligament mechanical properties caused by fluctuations in female sex hormones may increase the risk of ACL injuries and PFPS.[65] Tenan *et al*.[57] showed that the vastus medialis and vastus medialis oblique initial firing rates vary throughout the menstrual cycle.

Diagnosis

PFPS is a common cause for anterior knee pain and mainly affects young women without any structural changes or significant pathological changes in the articular cartilage. Therefore, PFPS is often known as a diagnosis of exclusion.[66] Patients with PFPS often describe pain behind, underneath, or around the patella.[1] The symptoms are usually gradual and pain in the anterior knee is the primary symptom of PFPS, although some patients also report instability and crepitation of the patellofemoral joint, specifically during loading of the joint and palpation of the patella. The pain increases after prolonged sitting, squatting, kneeling and stair climbing. PFPS is defined as anterior knee pain or retropatellar pain after at least two of these activities: ascending and descending stairs, hopping, jogging, prolonged sitting, kneeling and squatting.[67] PFPS also excludes peripatellar tendonitis or bursitis, plica syndromes, Sinding Larsen's disease, Osgood Schlatter's disease, and neuromas.

Patellar subluxation, dislocation, or prior surgery may lead to articular cartilage injury which also results in anterior knee pain. Risk factors for PFPS in females include overuse, trauma, muscle dysfunction, tight lateral restraints, patellar hypermobility, and poor quadriceps flexibility (Table 2).

Treatment approaches

Most treatment approaches for PFPS are conservative and surgical interventions are much less common (Table 3). There are a wide variety of treatment programs for PFPS but key components involve increasing strength, flexibility, proprioception, endurance, function training and gradual progression.[8] A multimodal nonoperative therapy with short-term use of NSAIDs, medially directed tape, and complex exercise programs with the inclusion of the core, lower extremity, and hip and trunk muscles has been shown to be the best course of treatment.[8]

Non-surgical interventions

Females with PFPS had lower eccentric hip abduction and adduction peak torque and higher eccentric adduction to abduction torque ratios when compared with controls. Thus, clinicians should consider eccentric hip abduction strengthening exercises when developing rehabilitation programs for females with PFPS.[68] Adding a core muscle-strengthening program to the conventional physical therapy management can help improve pain and dynamic balance in female patients with patellofemoral pain syndrome.[69] DeHaven *et al*.[10] reported that 89% of athletes were able to return to athletic activity after a treatment program that consisted of symptomatic control, a progressive resistance program of isotonic hamstrings and isometric quadriceps exercises, a graduated running program and a maintenance program. Reduction of loading to the patellofemoral joint and surrounding soft tissues by limiting exercise is primary to reducing pain. Substitute activities such as bicycling, swimming, or elliptical should be encouraged. Icing can be beneficial but heat is generally not recommended.

Weakness of the hip musculature may be a risk factor for PFPS; therefore, a proximal strengthening program is recommended. In a study by Earl *et al.,*[70] nineteen females with PFPS participated in an eight-week program aimed at strengthening the hip and core musculature and improving dynamic malalignment. They reported significant improvements in pain, functional ability, lateral core endurance, hip abduction and hip external rotation strength. They also observed a significant decrease in knee abduction moment during running. These results suggest that an exercise plan that focuses on strengthening and improving neuromuscular control of the hip and core muscles produces positive results in female

Table 1. Patellofemoral pain syndrome (PFPS): summary.

Definition of PFPS	1) Retropatellar pain during stairs, hopping/jogging, prolonged sitting, kneeling, squatting. 2) Negative findings on examination of knee ligament, menisci, bursa, synovial plica. 3) Pain on palpation of patellar facets, femoral condyles.
Incidence/Prevalence	1) Females are twice as likely to develop PFPS compared to males. 2) 70% of cases are between the ages of 16 and 25

Table 2. Reasons for increased susceptibility of patellofemoral pain syndrome in females.

Increase static	q-angle
Increase dynamic	Knee valgus angle; hip internal rotation angle; hip abduction moment; knee valgus moment
Decrease dynamic	Knee flexion angle
Weaker strength of	Quadriceps; hip external rotation; hip extension; hip abducto

Table 3. Patellofemoral pain syndrome treatment options.

Surgical	Non-surgical
Lateral Retinacular Release	Relative Rest
Proximal Realignment Procedures	Physical Therapy
Distal Realignment Procedures	Proximal Strengthening
Elevation of Tibial Tubercle	Gait Retraining
Anteromedial Tibial Tubercle Transfer & Elevation	Analgesics
Articular Cartilage Procedures	Bracing
Patellectomy	Patellar Taping

patients, improves the strength of the hip and core muscles, and reduces knee abduction moment, all of which are associated with the development of PFPS.[70]

There is a large amount of evidence that PFPS is at least partially due to faulty mechanics of the lower extremity.[71] Over time, repetitive exposure to motions such as increased hip adduction and femoral internal rotation may damage or overload the cartilage in the knee joint, which leads to the chronic pain of PFPS.[71] The goal of gait retraining involves adopting new gait patterns and it can be a successful therapy for reducing pain and improving function in PFPS patients as well as long-term improvements.

Although nonsteroidal anti-inflammatory drugs (NSAIDs) are commonly prescribed for patients with PFPS, there is little evidence supporting their effectiveness.[72] NSAIDs or acetaminophen may be considered for patients whose symptoms cannot be reduced by icing. Furthermore, a variety of braces, sleeves, and straps have been used in the treatment of PFPS. Although bracing alone may provide some symptomatic relief, studies have not found a benefit when bracing is used in addition to physical therapy.[73]

The recommended approach for patellar taping described by McConnell[74] is widely cited in treatments for PFPS. Werner *et al*.[75] found that patients who had patellar hypermobility were able to increase their knee extensor torque by taping. In contrast, Cerny *et al*.[76] reported that the ratio of vastus medialis obliquus to vastus lateralis as measured by elecrtromyographic activity was not improved with patellar taping. Hence further research is needed to determine whether patellar taping is beneficial in the treatment of PFPS.

Operative intervention

Although surgical interventions are typically not performed due to a wide range of effective conservative treatments available for PFPS, there are a number of surgical procedures that can be performed. Most of these surgical interventions aim at treating malalignment or injured cartilage. Surgical consultation for PFPS may be considered for those patients whose symptoms persist despite completing 6-12 months of conservative management with both formal and home exercises and rehabilitation.

Lateral retinacular release is performed when there is lateral compression syndrome with tenderness and tightness of the lateral retinaculum which is combined with lateral patellar tilt.[67] Fulkerson et al used CT images to compare patella tilt in patients before and after the lateral release and found that the lateral release effectively reduces abnormal patella tilt.[77] Fabbriciani *et al*.[78] found 71% of all patients with patellofemoral pain and presence of patella tilt had satisfactory outcomes after the lateral release procedure. There is a fine balance between too little of a release that will cause persistent pain or too much release that may result in medial patella instability.[79] Additionally, this procedure is not recommended for very young patients, those with advanced patellofemoral osteoarthrosis or patients with normal patellar tracking or patellar tilt.

Proximal realignment procedures are rarely used but are indicated for skeletally immature patients with a history of recurrent dislocations, patients with an increased congruence angle and patients with dysplastic femoral trochlea and poor medial patellar support of the vastus medialis obliquus muscle which leads to recurrent patellar subluxations or dislocations.[80]

Distal realignment or tibial tubercle osteotomy procedures are generally performed on patients with recurrent patellar dislocation or subluxation. Indications for distal realignment procedures include persistent patellofemoral pain coupled with excessive patellar tilt, subluxation or increased congruence angle, as well as lateral facet osteoarthrosis in the setting of increased distance between the Tibial Tubercle and the Trochlea Groove (TT-TG). Less than 10% of all patients with PFPS will need a distal realignment procedure. There are several methods for distal realignment, with the most common one being the Fulkerson osteotomy. A 5 to 7 cm bone pedicle is osteotomized at the distal tibial tubercle and the pedicle is moved both anteriorly and medially. The amount of anteriorization versus medialization is dependent on the steepness of the osteotomy cut. The other classic distal realignment also includes the Elmslie-Trillat procedure and Hauser procedure which involves medial translation of the distal tibial tubercle without anterior translation. The Maquet procedure involves anterior translation of the tibial tubercle without medialization to decrease patellofemoral contact forces. Concomitant articular cartilage procedures may also be indicated and include open or arthroscopic shaving of the patella, local excision of defects with drilling of the subchondral bone, and transplantation of autologous chondrocytes or osteochondral allograft procedures.[81] Indications for these procedures are dependent on the status of the cartilage at the time of surgery and is beyond the scope of this review article.

Conclusions

PFPS is one of the most common knee complaints in young healthy female athletes. However, both researchers and clinicians struggle to understand the factors that underlie PFPS because PFPS is often multifactorial in nature and may vary from patient to patient. From a review of the current literature, it is clear that there needs to have further research on PFPS in order to better understand the complex etiology of this disorder in both males and females. Females with patellofemoral pain syndrome demonstrate a decrease in abduction, external rotation and extension strength of the affected side compared with healthy controls.[48] Due to the complex nature of PFPS, a multitude of treatment approaches have been suggested. However, there is not yet a clear consensus among clinicians regarding the optimal treatment of PFPS. Factors contributing to PFPS include lower extremity malalignment, patellofemoral tilt or balance, muscle imbalance, and soft tissue or cartilage abnormalities. Optimizing the muscle balance between the vastus medialis and lateralis around the patella with formal and home directed therapy should be the first line of treatment in patients presenting with PFPS. Surgery should be reserved for patients with persistent knee pain with defined lesions within the knee, abnormal tilt, and malalignment despite trying all avenues of conservative treatment options.

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