Catherine Jacobs

PHYT 875 Final Paper

12/5/13

Patellofemoral Pain Syndrome

**Introduction**

Patellofemoral pain syndrome (PFPS) is a common cause of anterior knee pain.1 Multiple factors may affect motion of the patella in the trochlear groove and lead to pain. Anterior knee pain is common among physically active adolescents and young adults.2 Up to 40% of clinical visits for knee problems and 25% of all sports-related knee injuries are due to PFPS.3,4 Women are affected two times more frequently than men.1 Patients may experience pain with activities such as running, squatting, jumping, and climbing stairs.1,5 Other symptoms include crepitus, pain with full flexion, locking and/or buckling of knee, or stiffness.1,5 Multiple variables can increase stress on cartilage and subchondral bone and lead to maltracking of the patella and patellofemoral pain.4 Pain may develop at the insertion of the extensor mechanism or within subchondral bone.1,4 Several other conditions may cause anterior knee pain, so PFPS should be distinguished from intra-articular pathology, peripatellar tendinitis or bursitis, plica syndromes, Sinding Larsen’s disease, Osgood Schlatter’s disease, runners knee or neuromas.2,5 As this condition may limit participation and lead to osteoarthritis, clinicians should address PFPS.3

**Anatomy of the Patellofemoral Joint**

 The patellofemoral joint is formed between the patella and the patellar groove of the femur.6 The patella serves as a lever arm, increasing the moment arm of the patellar tendon and improving extension capacity of the quadriceps.2,6 The patella also helps to centralize the forces of the quadriceps muscle to the patellar tendon.6 As the largest sesamoid bone, the patella also protects the tibiofemoral joint.6 The patella has several articulating surfaces, mainly on the proximal two-thirds of the patella.6 The trochlear groove articulates with the patella through knee flexion.6 This joint is subject to compressive and tensile forces.6 Dynamic position of the patella can be affected by the geometry of these bony components as well as active muscles and passive connective tissue.2 Understanding this anatomy will help assess abnormalities and potential causes of patellofemoral pain.

**Etiology**

Various factors related to the lower extremity may contribute to the development of PFPS. Factors directly related to the patellofemoral joint such as quadriceps strength, patella tracking, and quadriceps angle (Q-angle) must be considered. Distal and proximal factors such as hip stability and strength or foot and ankle mechanics may also affect knee mechanics. Overactivity can also increase risk for PFPS.2

Several factors of lower extremity alignment including femoral neck antetorsion, genu valgum, knee hyperextension, Q-angle, tibial varum, and excessive rear foot pronation are associated with PFPS.2 Rauh et al assessed 393 high school cross country runners and found that when the Q-angle is greater than 20 degrees, runners are 1.7 times more likely to have knee injury compared to runners with normal Q-angle (between 10-15 degrees).7 Conversely, other studies have found that Q-angle does not correlate with increased risk of PFPS caused by increased abduction moment.8,9 This suggests that maltracking of the patella could be a dynamic malalignment rather than structural.1 Dynamic valgus alignment is commonly seen in female athletes and may contribute to PFPS as it leads to lateralization of the patella.1 In a study evaluating young female basketball players, those who developed PFPS also demonstrated a dynamic valgus position of the knee, and potentially internally rotated femur and tibia, indicated by increased knee abduction moment.3

Foot and ankle mechanics, in particular rear-foot eversion, may lead to PFPS.1 Tibial internal rotation can also drive rear-foot eversion.1 In a study comparing individuals with PFPS to matched controls, differences in foot and ankle characteristics were identified.10 Individuals with PFPS demonstrated increased pronation, increased forefoot abduction as well as rear-foot eversion compared to controls.10 Increased pronation drives tibial and femoral internal rotation which increases lateral patellofemoral joint stress.10

Patellar malalignment and maltracking may also contribute to PFPS.1,2 This is often apparent when individuals with PFPS squat, as lateralization and increased lateral tilt of the patella is observed.1 An increased correlation also exists between hypermobility of the patella and incidence of patellofemoral pain.1,9 General ligamentous laxity has been explored in relation to patellofemoral pain. Over a 2 year prospective study, Witvrouw et al found individuals with patellofemoral pain had increased little finger extension, knee extension, shoulder mobility, and thumb-forearm mobility compared with healthy controls.9

Muscular imbalances in strength and flexibility relate to PFPS. Muscle strength and control of the vastus lateralis and vastus medialis can affect patella tracking. Witvroux et al found potential imbalance in muscle activation as individuals with PFPS walked up and down stairs; the vastus lateralis was activated before the vastus medialis obliquus.9 This imbalance was not seen in the control group.9 Individuals with PFPS also may demonstrate vastus medialis obliquus atrophy.1 In the sagittal plane, hamstring tightness and muscle imbalance may contribute to PFPS.1 Studies have indicated that in patients with PFPS the lateral hamstrings contract earlier than medial hamstrings during isometric contraction, and that there is greater co-contraction of the quadriceps and hamstrings.1 This may lead to increased joint contact force and stress on the patella and supporting structures.1

As the hip influences the knee, hip stability and abductor strength can influence PFPS. Functional malalignments at the knee may begin with internal rotation of the femur as a result of weak hip external rotators and abductors.1 Gluteal muscle strength can affect knee position with jumping.1 A recent systematic review found a correlation between decreased hip abduction, external rotation, and extension strength in females with PFPS compared to healthy controls.11

Tight soft tissues can influence motion of the patella. Tightness in the quadriceps can increase patellofemoral stress.4 ITB tightness may also relate to PFPS development, especially related to patellar tracking and dynamic malalignments.1,4 Fibers of the ITB attach to the lateral retinaculum so shortening of the ITB may also affect the lateral retinaculum.4 When the ITB is tight, the patella is pulled laterally with knee flexion, increasing patellofemoral joint reaction forces.4

Understanding these potential mechanisms is important because anterior knee pain can create a negative cycle. The patellofemoral joint can be overloaded by mechanisms such as dynamic valgus and lateralization of the patella, leading to anterior knee pain.1 This can affect the muscle activity of the lower extremity which can prolong the mechanism of injury. Identifying if someone has hip abductor weakness, quadriceps weakness, abnormal patellar mobility, irregular lower extremity alignment, or soft tissue tightness will help individualize a treatment plan to reduce patellofemoral pain.

**Evaluation**

 The multifactorial causes of patellofemoral pain make evaluation challenging. No single gold standard test exists for PFPS and physical examination may only reveal subtle changes.4 Understanding what potential mechanisms of pain may be and how to assess them is important in order to cluster objective findings and guide treatment.

 Taking a thorough history will help understand knee pain. Questions may include prior injury to the lower extremity, family history of knee pain, and descriptions of current pain. As posture is observed, the following observations could contribute to PFPS: subtalar joint pronation, genuvarum, valgum, or recurvatum, medial or lateral shift of patella, prominent ITB, anterior pelvic tilt/lumbar lordosis, forward posture.5

 Palpation of the knee should assess location of pain including commonly reported locations such as the lateral retinaculum and vastus lateralis insertion.4 Crepitus may be observed with PFPS, but is not diagnostically significant as it is also common in asymptomatic knees.4 General ligamentous laxity may be assessed using the Beighton Score.4

Q-angle describes the angle between the line of pull of the quadriceps and the patellar tendon, as they intersect at the center of the patella.4 If the Q-angle is increased, the patella is more likely to lateralize as the quadriceps contract. The Q-angle can be measured in sitting, standing or supine, with the foot and leg in neutral position.4 By measuring from the ASIS to the center of the patella connecting with the line between the center of the patella to the middle of the tibial tuberosity, the Q-angle can be measured in supine.4 By measuring in standing, the foot position will be standardized.4 It’s important the leg is in neutral rotation and the patella is in the middle of the trochlea to increase reliability of measurement.4

Several tests can assess the patella. A patellar tilt test can assess for lateral tilt which increases forces on lateral patellofemoral joint.4 In supine with the knee extended and quadriceps relaxed, the height of the medial and lateral patellar borders are examined.4 Mediolateral glide also describes patellofemoral orientation.4 Glide can be measured from midpatella to both medial and lateral femoral epicondyles; at 20 degrees knee flexion the patella should be equidistant.4 Passive patellar mobility with knee flexed 20-30 degrees and quadriceps relaxed assesses tightness and integrity of medial and lateral restraints.4 This can be affected by tight structures such as the iliotibial band, or generalized laxity.4 An apprehension test can assess for patellar instability; lateral pressure is applied to the medial patella, and the patient may attempt to straighten knee out of 30 degrees of flexion.4 Patellar compression will likely be positive, but specificity is questionable as both knees are often positive with testing.4 Dynamic patellar tracking can indicate instability, as the patient actively extends the knee from 90 degrees to full extension.4 The patella should move straight proximally with only slight lateral shift at terminal extension; a “J sign” may describe poor tracking as the patella deviates laterally and subluxes at terminal extension in an inverted J shaped path.4

 As several studies have demonstrated association of flexibility and strength and PFPS, these factors should be assessed. Flexibility of the quadriceps can be assessed in prone with Ely’s test. Ober’s test can assess ITB tightness. Strength deficits may be seen in PFPS when comparing affected to unaffected knee.4 Quadriceps weakness is common, but not always seen in PFPS.4 Hip abduction and external rotation are often weaker on the affected side.4 Typical manual muscle testing positions can be used. Functional tests may also be used to simulate weight bearing demands. To assess functional malalignment or dynamic valgus, the ability to perform single leg squats may indicate weak hip abductors.1 To examine pelvic stability and hip muscle strength, a patient should be able to maintain SLS with hips level for one minute.1 Anteromedial lunge, step downs, single leg press, bilateral squat, and balance and reach are all functional tests that have been associated with changes in pain in patients with PFPS.4

 Various outcome measures can be used to track improvement. As pain is a main symptom of PFPS, this can be tracked. Function should be assessed through completion of activities of daily living, or sporting activities. Multiple questionnaires may be used to focus on knee functioning including the Functional Index Questionnaire, WOMAC Osteoarthritis Index, and Kujala Patellofemoral Function Scale, etc.12 Functional tests, as discussed above, should be considered when assessing functional disability.12 While ROM and MMT should be tracked, these may not directly represent changes related to PFPS.

**Treatment**

 Rehabilitation of PFPS should restore alignment and function of the lower extremity. Because etiologies can be diverse, treatment should be individualized. Conservative treatment is recommended initially in PFPS.1 Surgical options are available, but studies do not demonstrate significant improvement compared to conservative management. Kettunen et al performed a RCT to compare knee arthroscopy and exercises to exercise only in treating chronic PFPS.13 Arthroscopy can be used to diagnose cause of PFPS and then perform surgical repairs.13 Exercise included 8 week home exercise program directed by physical therapists, focusing on lower extremity strengthening and stretching.13 At nine month follow up, both groups showed improvements in various measures including the Kujala score and visual analog scales to assess activity related symptoms; however, there was no difference between groups.13 These findings show that there is not additional benefit with arthroscopy in addition to exercise.13

 While surgical intervention is not a recommended first line of treatment, it is still beneficial to review various options. Arthroscopic repair is typically recommended only when there is known osteochondral injury.14 While PFPS can be caused by dynamic changes, factors such as trochlear dysplasia, lateralized tibial tubercle, and/or patellar deformities are structural causes of pain and instability.14 Medial patellofemoral ligament repair is one potential intervention to improve lateral patellar constraint.14 Using dislocation rates to compare outcomes, no difference is seen compared to conservative treatment.14 The lateral retinaculum, which courses between the distal ITB and superior lateral patella, can be tight and affect patellofemoral alignment.14 Surgical options include a release or lengthening of this tissue. A release can lead to instability, and should only be indicated with significant lateral compression or positive patellar tilt test.14 The trochlea is the major lateral stabilizer of the patellofemoral joint after the knee is flexed beyond 30 degrees.14 Trochleoplasty increases stability of the patellofemoral joint, but is a difficult surgical technique.14 If the tibial tubercle is lateralized an osteotomy can be performed to lower the patella and reduce the Q-angle to reduce force and pressure.14 If femoral antetorsion is greater than 20 degrees, this can contribute to anterior knee pain and instability; surgery manipulates the femur to better fit with the patella.14

Several conservative treatment options are available to manage PFPS. The goal of taping is to improve patellar tracking and allow individuals to exercise pain free.15 By applying a medially directed force, this should balance the lateral patella maltracking.1 Taping can be used to affect glide, tilt, and/or rotation.15 Pfeiffer et al studied the effectiveness of McConnell medial glide taping after exercise in 18 healthy women.15 Lateral patellar displacement was measured by imaging the patellofemoral joint at various angles of knee flexion with no tape, with tape and taping after exercise (including sprints, minisquats, shuffling, etc).15 Results indicate that McConnell medial glide taping does affect tracking and lead to significant medial glide of the patellofemoral joint at all angles before exercise, but taping was unable to maintain medial patellar position after exercise.15 This suggests that decreased pain seen with taping may be not be from patellar alignment, but potentially other mechanisms such as improved contact surfaces or muscle activation.15 Current evidence suggests tape may be a temporary relief to pain, as no long term effects have been studied.16 Tape and exercise together may be more beneficial than tape alone.1 Several studies have indicated taping has positive effect on symptoms of PFPS including pain, although further research should assess preliminary findings related to quadriceps function.1,16

 Patellar braces act similarly by applying a medially directed force to control lateral patellar maltracking.16 A systematic review by Warden et al found only three studies on bracing, which suggested medially directed bracing reduced pain more than no brace, although medially directed bracing did not differ from sham brace.16 Caution should be taken with long term wear of braces as this could lead to quadriceps atrophy.5 It is also suggested that a brace has a cut out to allow patellar motion and avoid pressure to the patella.5 Higher quality studies are needed to make conclusions about bracing for patients with PFPS.

As rear-foot eversion and pronation are correlated with PFPS, orthotics are another potential treatment option to correct malalignment. Petersen et al found differing results on the effectiveness of foot orthoses. Potential predictors of those who respond positively to foot orthotics include body height less than 165cm, age older than 25, lower pain levels, midfoot abnormalities, and greater rear-foot eversion.1 Orthotics may be used in combination with exercises to improve pain as well as functional outcomes such as number of step downs.1

 Physical therapy and exercise are commonly prescribed to improve PFPS. In order to improve patellofemoral mechanics, this may include strengthening appropriate muscles, achieving full joint mobility throughout the lower extremity, and stretching tight tissues. As discussed above tightness in the ITB, hamstrings, quadriceps or calves can all affect PFPS, and should be addressed.5 Patellar mobilization can be performed to improve mobility. Important muscles to consider strengthening include hip abductors and quadriceps. As neuromuscular control may be affected in PFPS, this should be considered. Exercises should progress in all planes so that patients can resume normal activity.5

A systematic review by Heintjes et al evaluated 12 studies regarding exercise therapy for patients with PFPS.12 Findings included significantly decrease in pain in exercise groups, effectiveness of both open and closed kinetic chain exercises, but inconsistent results in functional measures.12 A more recent systematic review by Harvie et al found positive results for exercise interventions that focus on lower extremity strengthening, with flexibility exercises and more consistent improvements in functional measures.17 Stretching was a component in 8 of the 10 trials; all studies that specified muscles stretched included hamstrings and quadriceps, others also included gastrocnemius, ITB, and anterior hip stretches.17 Strengthening included various activities such as knee extension, squats, stationary cycling, static quadriceps exercises, active straight leg raises, leg press, and step up and down exercises to promote quadriceps, gluteals, hip abductors, hip external rotators, and occasionally hip adductor strength.17 Specific recommendations are made for daily exercise of 2-4 sets of 10 repetitions over at least 6 weeks of intervention.17 Therapists can prescribe specific exercises as well as utilize the interventions described above such as taping, patella mobilizations, and education about PFPS. While the evidence continues to grow, exercise is effective in reducing pain and increasing functional ability for individuals with PFPS.17

**Conclusion**

 Patellofemoral pain can be multifactorial in nature and evaluation and treatment reflect this. Causes may relate to the patellofemoral joint such as muscle strength and control, patella tracking, and lower extremity alignment. Strength, flexibility, and alignment of the hip and ankle are important to consider. Because no precise etiology of PFPS exists, treatment options can be diverse. Conservative management is first line of treatment of PFPS. This may include taping, foot orthotics, and exercise. Further research should continue to identify the most effective interventions and identify long term results. Physical therapy and exercises are commonly prescribed and effective methods of managing pain and decreased function related to PFPS.

**References**

1. Petersen W, Ellermann A, Gösele-Koppenburg A, et al. Patellofemoral pain syndrome. *Knee Surg Sports Traumatol Arthrosc*. 2013. Epub ahead of print. doi: 10.1007/s00167-013-2759-6.
2. Thomeé R, Augustsson J, Karlsson J. Patellofemoral pain syndrome: a review of current issues. *Sports Med*. 1999;28(4):245-62.
3. Myer GD, Ford KR, Barber Foss KD, et al. The incidence and potential pathomechanics of patellofemoral pain in female athletes. *Clin Biomech*. 2010;25(7):700-7.
4. Fredericson M, Yoon K. Physical examination and patellofemoral pain syndrome. *Am J Phys Med Rehabil*. 2006;85(3):234-43.
5. Green ST. Patellofemoral syndrome. *Journal of Bodywork and Movement Therapies*. 2005;9:16-26.
6. Tecklenburg K, Dejour D, Hoser C, Fink C. Bony and cartilaginous anatomy of the patellofemoral joint. *Knee Surg Sports Traumatol Arthrosc*. 2006;14(3):235-40.
7. Rauh MJ, Koepsell TD, Rivara FP, Rice SG, Margherita AJ. Quadriceps angle and risk of injury among high school cross-country runners. *J Orthop Sports Phys Ther*. 2007;37(12):725-33.
8. Park SK, Stefanyshyn DJ. Greater Q angle may not be a risk factor of patellofemoral pain syndrome. *Clin Biomech*. 2011;26(4):392-6.
9. Witvrouw E, Lysens R, Bellemans J, Cambier D, Vanderstraten G. Intrinsic risk factors for the development of anterior knee pain in an athletic population. A two-year prospective study. *Am J Sports Med*. 2000;28(4):480-9.
10. Barton CJ, Bonanno D, Levinger P, Menz HB. Foot and ankle characteristics in patellofemoral pain syndrome: a case control and reliability study. *J Orthop Sports Phys Ther*. 2010;40(5):286-96.
11. Prins MR, van der Wurff P. Females with patellofemoral pain syndrome have weak hip muscles: a systematic review. *Aust J Physiother*. 2009;55(1):9-15.
12. Heintjes E, Berger MY, Bierma-Zeinstra SM, Bernsen RM, Verhaar JA, Koes BW. Exercise therapy for patellofemoral pain syndrome. *Cochrane Database Syst Rev*. 2003;4:CD003472.
13. Kettunen JA, Harilainen A, Sandelin J, et al. Knee arthroscopy and exercise versus exercise only for chronic patellofemoral pain syndrome: a randomized controlled trial. *BMC Med*. 2007;5:38.
14. Tscholl PM, Koch PP, Fucentese SF. Treatment options for patellofemoral instability in sports traumatology. *Orthop Rev (Pavia)*. 2013;5(3):e23.
15. Pfeiffer RP, DeBeliso M, Shea KG, Kelley L, Irmischer B, Harris C. Kinematic MRI assessment of McConnell taping before and after exercise. *Am J Sports Med*. 2004;32(3):621-8.
16. Warden SJ, Hinman RS, Watson MA Jr, Avin KG, Bialocerkowski AE, Crossley KM. Patellar taping and bracing for the treatment of chronic knee pain: a systematic review and meta-analysis. *Arthritis Rheum*. 2008;59(1):73-83.
17. Harvie D, O’Leary T, Kumar S. A systematic review of randomized controlled trials on exercise parameters in the treatment of patellofemoral pain: what works? *J Multidiscip Healthc*. 2001;4:383-392.