

**Systematic Dissection and Critical Literature Review
of the
Patellofemoral Joint**

By

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An Honors Project Proposal

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Abstract

Patellar instability(PI) is a pathology of the patellofemoral joint(PFJ), which consists of the articulation between the patella and the distal femur. It commonly results in recurrent subluxations and dislocations throughout the patient's lifetime. Study of predisposing factors reveals extreme anatomies effecting ligamentous, osseous, and muscular stability, which make a patella more susceptible to instability. In this literature review, the following were studied: history, epidemiology, morphology, etiology/pathogenesis, treatment, and contraindications. Cadaveric dissection was used to understand joint function, congruence and typical anatomy of the PFJ.

Introduction/Background

Patellar instability (PI) is a precedent to possible sequelae that over time can disable the active person. The implications of this pathology have been experienced on a personal level. Three different times my patellar instability has led to subluxation, the first occurring during snowboarding as depicted in Figure 1, leading to an invasive surgery at 13 years old. I was forced to discontinue sports that required cutting and twisting in order to prevent further episodes of patellar luxation and increased instability. In light of this life altering experience this study was undertaken to clearly master the precipitating elements and the science behind the medical responses to this set of pathologies that plague so many active people. Standard of care in diagnosis and treatment were explored.

This project explored the etiology and predispositions that make a person susceptible to patellar instability. Particular attention has been brought to the extreme anatomy that a person may exhibit, making them particularly vulnerable. As well physiological hormonal influences were studied as it relates to epidemiology. In order to understand normal anatomy of the Patellofemoral Joint (PFJ), cadaveric dissection was undertaken, exploring the muscular, osseous, and ligamentous structure of the femur in its relation to the patella. Treatment options and subsequent prognosis of these treatment options were studied and presented. Because orthopedic knowledge of the PFJ is still progressing, contraindications and controversial treatment options were explored in order to present current professional discourse.



Figure 1: Depiction of a heel side turn during snowboarding and the vulnerable knee.¹

Cadaveric Dissection

In order to understand the complexity of the knee it was imperative to conduct a cadaveric dissection of the tibiofemoral joint and the PFJ. An understanding of the anatomy of the knee that goes beyond diagrams and textbooks was attained through the dissection of a human cadaver. Lower extremity dissection allowed for identification of the ligamentous structures, bony prominences, and muscles of the knee in relation to one another, as well as their structure and function. Dissection provided further knowledge of tendon attachment points and ligament attachment sites and the functional ramifications. Ligamentous structure of particular importance in the PFJ is the medial patellofemoral ligament (MPFL), which identified in the cadaveric dissection, is integrated into the fascia of the MCL as observed in Figure 2. An apprehension test of the patella was applied to the patella to observe stability both laterally and medially. The most common pathological luxation is a lateral pathway of the patella out of the trochlear groove as presented in

Figure 3. Incisions were made to observe the intraarticular aspects of the PFJ. Severing of each ligament was used to study the effects on ligamentous stabilization.

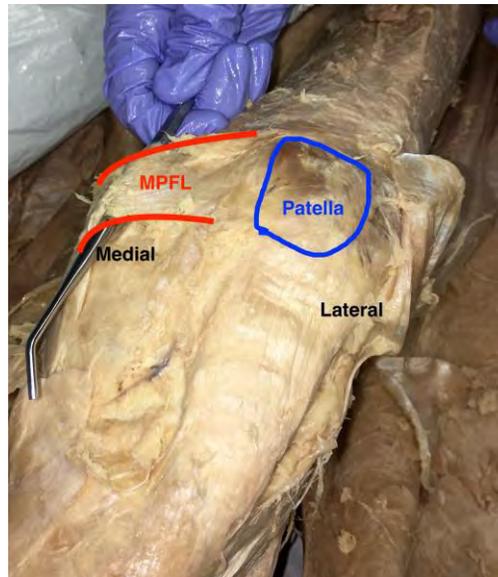


Figure 2: The MPFL and its anatomical attachment to the Patella as observed in cadaveric dissection.

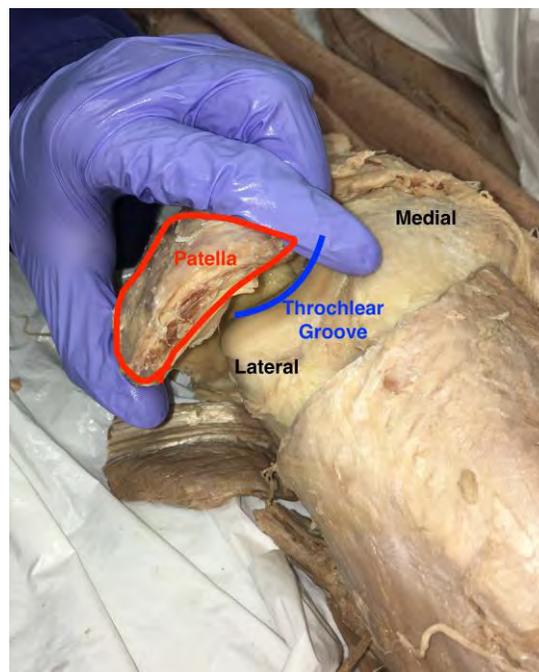


Figure 3: The movement of the patella out of the trochlear groove during luxation as noted in cadaveric dissection.

Morphology

In the PFJ, the ligaments attach and stabilize the patella in trochlear groove of the femur. The major ligament, as seen in Figure 4, comprises the inert stabilizing structure of the PFJ, the medial patellofemoral ligament (MPFL). The MPFL is the primary stabilizing influence of the patella. This ligament attaches from the medial femoral condyle to the medial border of the patella. This anatomical location makes it a primary lateral restraint, preventing lateral tracking of the patella and subsequent dislocation or subluxation. In the first 30 degrees of PFJ flexion, the MPFL provides 50 to 60% of this lateral restraint. In a study of cadavers, there was a 50% decrease in the amount of force that is required to move the patella laterally when the MPFL was severed.²



Figure 4: A depiction of the MPFL from an anterior prospective of the knee and subsequent attachment site on the medial border of the patella.³

The osseous structure of the PFJ is uniquely shaped to provide bony support for the patella. The trochlear groove is structured to guide the patella through a sagittal/oblique path during flexion and extension of the knee. This groove is called the trochlear groove or notch, patellofemoral groove, or femoral groove. Its structure is depicted in Figures 5 and 6.

The bony prominences on both sides of the groove are the lateral and medial condyles. During flexion, the lateral condyle becomes an important osseous stabilizing factor, because the patella most often tracks laterally. If trochlear dysplasia is present, the groove is abnormally shallow, decreasing the lateral structural support provided by the groove and as such the tensile strength of the MPFL is challenged.⁴ The location of the tibial tuberosity, which is the distal attachment of the patellar ligament, plays an important role in the tracking of the patella because its anatomical location influences the lateral force elicited on the patella by the quadriceps tendon. Alterations in the tibial tuberosity anatomy will be discussed in the Etiology section.

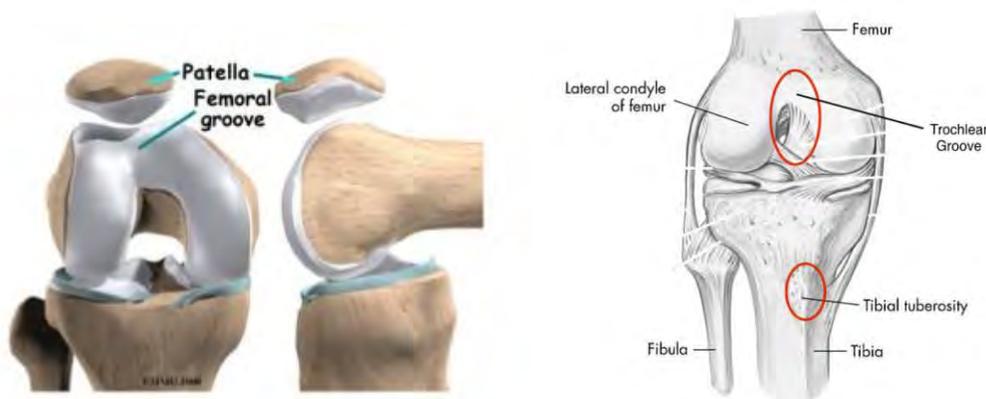


Figure 5 and 6: Depiction of the osseous structures of the PFJ including the trochlear groove and the tibial tuberosity.^{5,6}

There are four muscles in the quadriceps muscle group and they include: the vastus muscles lateralis, intermedius, and medialis, and the central and superficial rectus femoris. Of the four major muscles in the quadriceps muscle group the vastus medialis oblique (VMO) has the greatest influence on patellar stability. The VMO is a major source of stability, as its attachment point is on the medial border of the patella. It works in unity

with the MPFL because the lateral 1/3 of the MPFL is fabricated into the VMO via fasciae, thin fibrous tissue.⁷ In patellar stability, the contribution of this muscle is necessary to prevent the extreme lateral movement of the patella, which can culminate in lateral subluxation or luxation

The quadriceps muscles together play a primary role in the eccentric flexion and concentric extension of the knee. When these quadriceps muscles contract the knee extends, and when the quadriceps muscles relax, the knee is moved into flexion. The rectus femoris crosses two joint lines, the hip and knee joint, making it of particular importance in both hip and knee extension, as seen in Figure 7. It attaches at the ilium and extends all the way across the knee joint via the quadriceps tendon. The vastus medialis, vastus lateralis, and vastus intermedius, as seen in Figure 7, work in unison to extend the knee and give power in movements such as rising from a squat. All these muscles can be observed together in Figure 8. As mentioned earlier, the vastus medialis is significant in the stabilization of the PFJ because of its attachment point on the patella and guiding the patella with stabilization throughout flexion and extension.

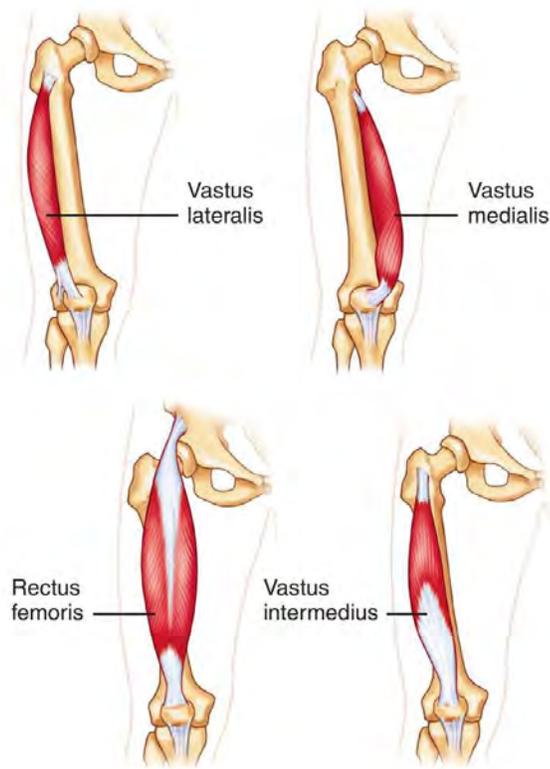


Figure 7: Anatomical Position of Quadriceps Muscles and Associated Insertion Points.⁸

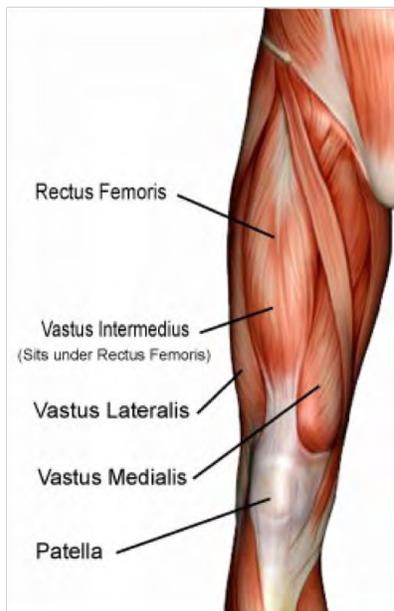
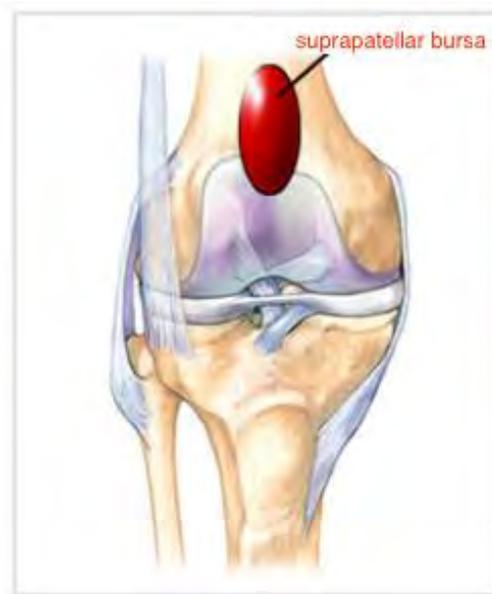


Figure 8: The four quadriceps muscles: rectus femoris, vastus lateralis, vastus intermedius, and vastus medialis in unison.⁹

The genu articularis is small muscle deep to the vastus intermedius, which pulls the suprapatellar bursa superior during extension of the knee to prevent impingement of the bursa. The Suprapatellar bursa, as depicted in Figure 9, is a portion of the synovial capsule of the knee and serves as an “emergency” reservoir in the event of joint effusion. The bursa changes profile in relationship to the sagittal position of the knee as depicted in Figure 10 due to contraction of the genu articularis. If it weren’t for a fully functioning genu articularis, as seen in figure 11, impingement of the bursa could occur during extension, resulting in synovitis.



Figures 9: The anatomical location of the suprapatellar bursa in relation to the trochlear groove during full extension.¹⁰

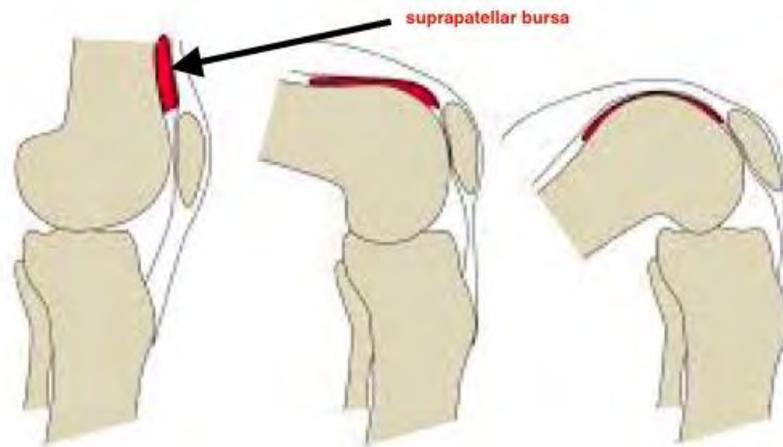


Figure 10: Movement of suprapatellar bursa through flexion and extension of the knee.¹¹

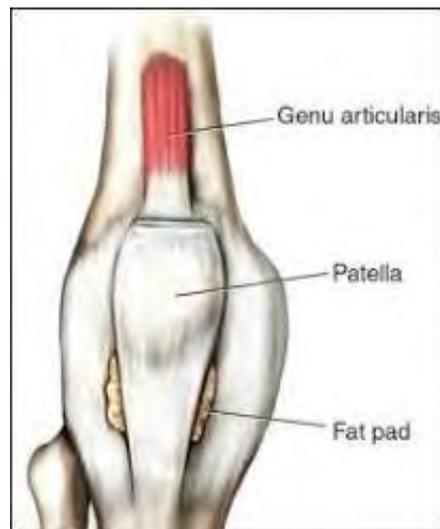


Figure 11: Anatomical location of the genu articularis.¹²

The quadriceps tendon consists of two different portions as seen in Figure 12. The quadriceps tendon is the entire tendon from the muscle tendon interface to the Tibial Tuberosity. Within the quadriceps tendon, the patellar tendon section consists of the

muscle tendon interface to the superior pole of the patella. The patellar ligament section consists of the attachment of the inferior border of the patella to the tibial tuberosity. The influence of the quadriceps tendon will be discussed further in the etiology section.

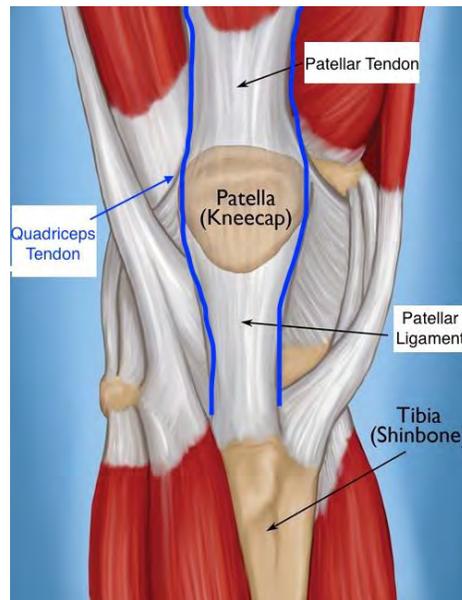


Figure 12: An anatomical depiction of the quadriceps tendon, patellar tendon, and patellar ligament.¹³

Epidemiology

Patellar dislocation is responsible for approximately 2 to 3 % of all knee injuries, and is the second major cause of hemarthrosis, bleeding within the knee joint which leads to pain and swelling.¹⁴ After a first time patellar dislocation, recurrent patellar instability is of greater concern, with 15 to 45% experiencing recurrent patellar dislocation. Persons who are patellar luxators without a family history are shown to have the highest rates of patellar instability episodes, which leads to the conclusion that patellar instability is not genetically influenced. Within the young, active population, certain activities have been

shown to have higher rates of patellar instability episodes, such as activities that create torsion on the patellofemoral joint (PFJ).¹⁵ Torsion is described as twisting, in this case the twisting of the PFJ. For instance, cutting motions in basketball, soccer, tennis etc. all involve movements that produce torsion on the PFJ. For this reason, young athletes in sports that involve fast, cutting movements, create a higher risk for patellar.

Data clearly indicates that females are more prone to patellar instability than their male peers. In a study by Alm et al¹⁶ out of 1765 first time patellar dislocations, the ratio of men to women was 46% men and 56% women. Patellar instability has been of major concern in female adolescents. In this demographic patellar dislocation occurs in approximately 29-43 out of 100,000, which is ten times greater than the rate of patellar dislocation in adults.¹⁶ Within adolescents patellar instability commonly occurs between 10 to 20 years old.^{14,17} Physically active adolescents are at highest risk for patellar trauma than their peers. Various studies focusing on sports injury found that as low as 55% and up to 72% of first time patellar dislocations occur during sporting activities.¹⁴ In habitual dislocations, simple activities such as climbing stairs, running, or standing up from a chair can make the patella more vulnerable, with only 3% of recurrent cases occurring from traumatic force.¹⁶

Pathogenesis/Etiology

Many people with patellar instability have risk factors for dislocation. Common structural risk factors include: patellar alta, trochlear dysplasia, excessive lateral tibial tuberosity position, genu valgus, ligamentous laxity, quadriceps atrophy, external tibial torsion, and increased femoral anteversion.¹⁸

Patella alta is defined as the superior placement of the patella, as seen in Figure 13. This superior placement means the patella is no longer congruent with the trochlear groove,

and therefore has lost a vital bony stabilizing factor, placing the patella at risk of dislocation or subluxation. A superiorly displaced tibial tuberosity or an anomalously long patellar ligament causes this. Feller¹⁹ cites Caton-Deschamps who provided an objective means of quantifying patella alta as seen in Figure 14. Using the AP/AT ratio in a flexed position where AT is the measure of the distance between the inferior border of the patella to the tibia, and AP is the measure of the articular surface of the patella (note that two different labeling practices are used in the literature), Caton-Deschamps identified a normal range to be with 0.6 to 1.2. Therefore anything above 1.2 is considered patella alta.¹⁹

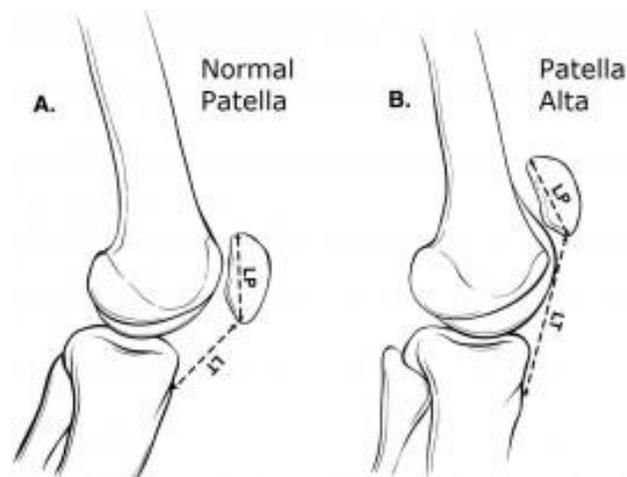


Figure 13: Anatomical position of a patella in patella alta.²⁰

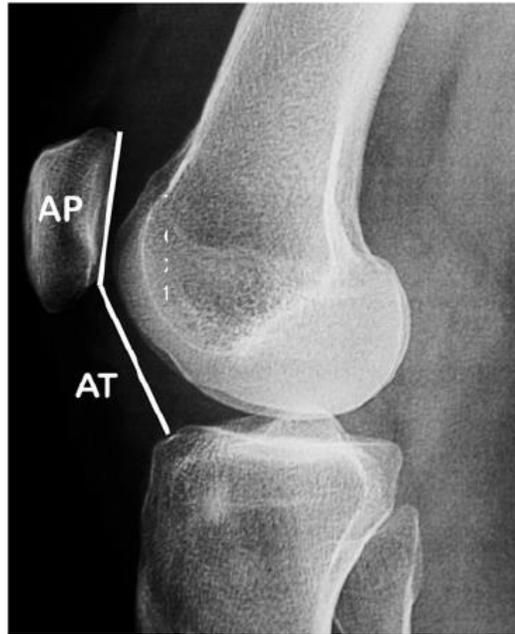


Figure 14: Measurements taken to calculate patella alta based on Caton-Deschamp's ratio.²¹

The anomaly of a laterally displaced Tibial Tuberosity can create an increase in the distance from tibial tuberosity (TT) to the anatomical line of the trochlear groove (TG) as seen in Figures 15 and 16. This is significant to patellar instability predisposition because as the TT-TG distance increases and the tibial tuberosity becomes more lateral, the force from the stretched patellar ligament places an increased lateral load on the patella. This force can cause the patella to travel laterally out of the trochlear groove, causing subluxation or luxation. Typically a distance of 20 mm or more is a significant indicator of patellar instability.⁷

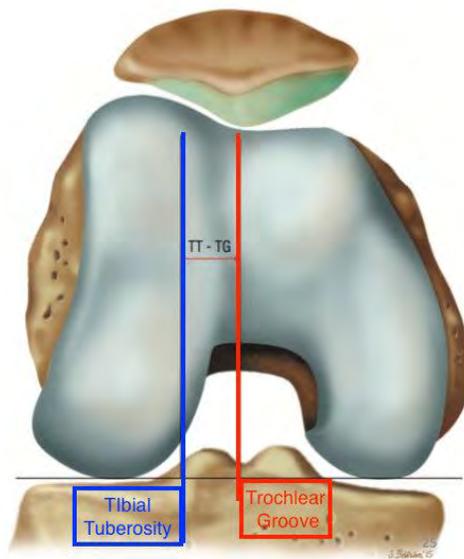


Figure 15: Measurements for TT-TG distance, which is measured from the line of the trochlear groove to the line of the anatomical position of the tibial tuberosity.²²

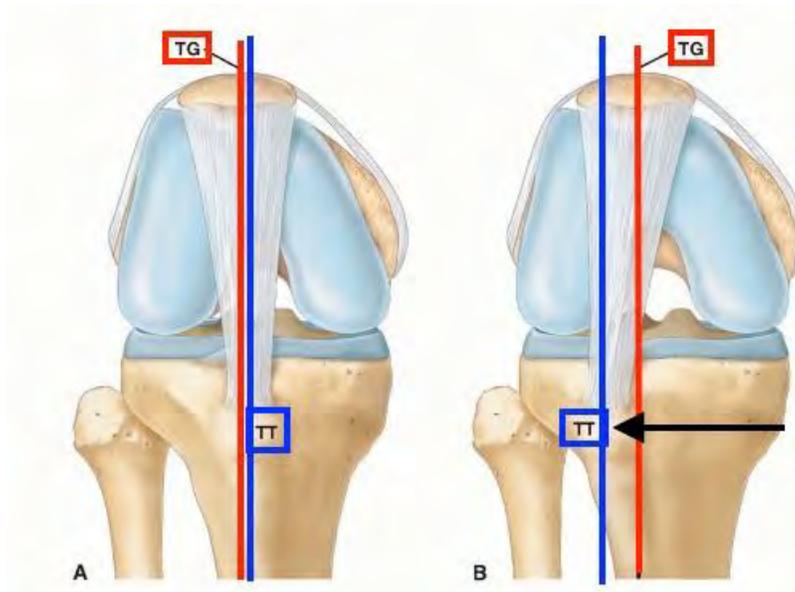


Figure 16: Normal TT-TG distance (A) as compared to abnormally lateral TT-TG distance (B).²³

The Q Angle is a quantification of the vulnerability to excessive lateral forces to which the patella is subjected. The technique of quantifying the Q angle can be seen in Figure 17. The first line segment is identified as the midpoint of the patella to the ASIS on the pelvis.

The second line segment is identified as the midpoint of the patella to the tibial tuberosity. Q-angle is the measurement of the angle formed by these two line segments. As the Q-angle increases, the force of the quadriceps increases the lateral pull on the patella. An extreme Q angle, which is more commonly seen in females than males, is a predisposition to patellar instability. As women mature, their hips become wider to adapt for carrying and delivering babies. As the hips widen, the Q-angle of the lower extremity also increases.²⁴ The average Q angle found in males is approximately 11 degrees, ranging from 9 to 14 degrees. The average Q angle found in females is 18 degrees, ranging from 15 to 22 degrees. This difference in Q angle is significant enough to render females more susceptible to patellar instability. This creates an abnormally great quadriceps contraction, which leads to subsequent knee injuries, such as dislocation and subluxation. One study found a correlation ($p < 0.05$) between Q-angle and the hip internal rotation, as well as anteversion of the PFJ.²⁵ This anteversion of the PFJ has been identified in other studies as a risk factor for patellar instability.¹⁸

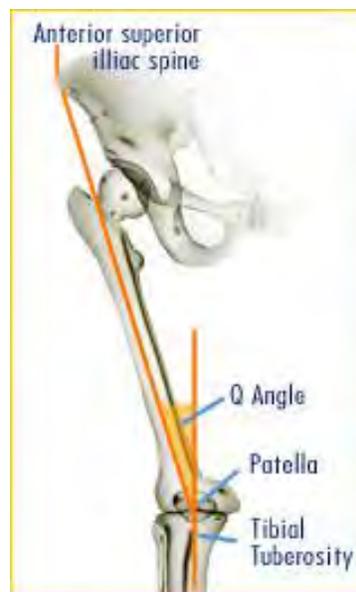


Figure 17: Measurement of the Q angle.²⁶

Femoral anteversion describes a posture of internal rotation of the femur. This is not a movement but state of position of which the subject is rarely aware. The root of this predisposition begins at the pelvis and progresses down the kinetic chain to cause internal rotation of the PFJ and pronation of the foot, which can be observed Figures 18 and 19. Femoral anteversion and the subsequent abduction of the PFJ, places the PFJ at an increased risk of patellar instability. The altered position of the joint increases the load on the quadriceps muscle via elongation and eccentric contraction. The contraction of the lateral quadriceps can exceed the stabilizing influence the VMO and MPFL, resulting in patellar dislocation or subluxation.⁷ When alignment of the lower extremity was evaluated during functional movements, the McKeon et al²⁷ study showed greater rates of femoral anteversion in females. This proved to show functional impairments, particularly in flexion as shown in Figure 20. This is because as landing and jumping were observed during the functional tasks, females exhibited less abduction at both the hip and knee, placing a greater strain on the knee joint.²⁷

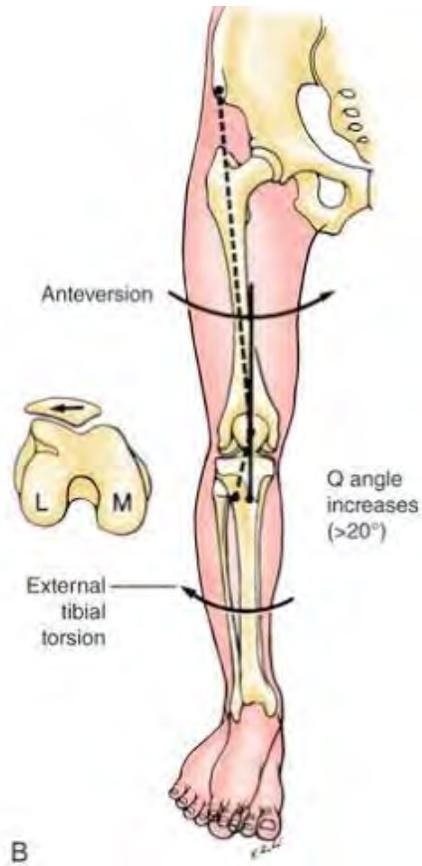


Figure 18: Anatomical alterations from femoral anteversion.²⁸

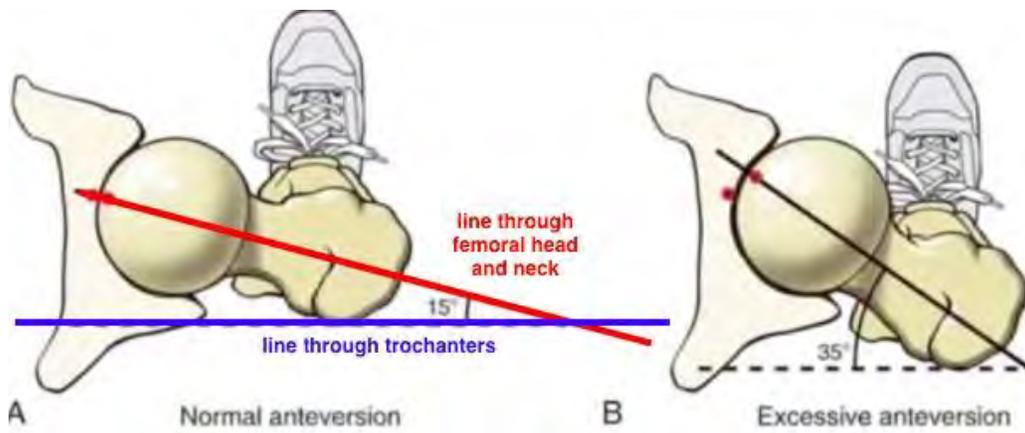


Figure 19: A transverse view of femoral anteversion in the hip, progressing down the kinetic chain.²⁹

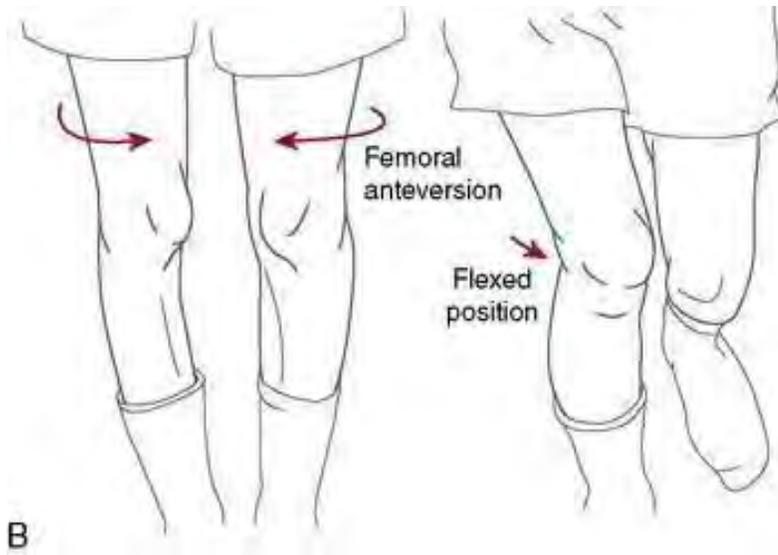


Figure 20: Femoral anteversion and its affect on functional movements.³⁰

Trochlear dysplasia is described as altered morphology of the lateral and medial condyles of the PFJ. Trochlear dysplasia puts a person at an 85% greater risk of PI.⁴ Classifications of trochlear dysplasia, classified by Dejour, can be observed in Figure 21. Grade A is a shallow trochlear groove. Grade B is a flat or convex trochlear groove. Grade C is characterized as having asymmetry between the medial and lateral femoral facets, in which the lateral facet is convex and the medial facet is hypoplastic. Grade D has asymmetrical trochlear facets, with a distinct cliff pattern.³¹ The presence of a hypoplastic medial border has been associated with higher rates of patellar luxation compared to other types of trochlear dysplasia.³²

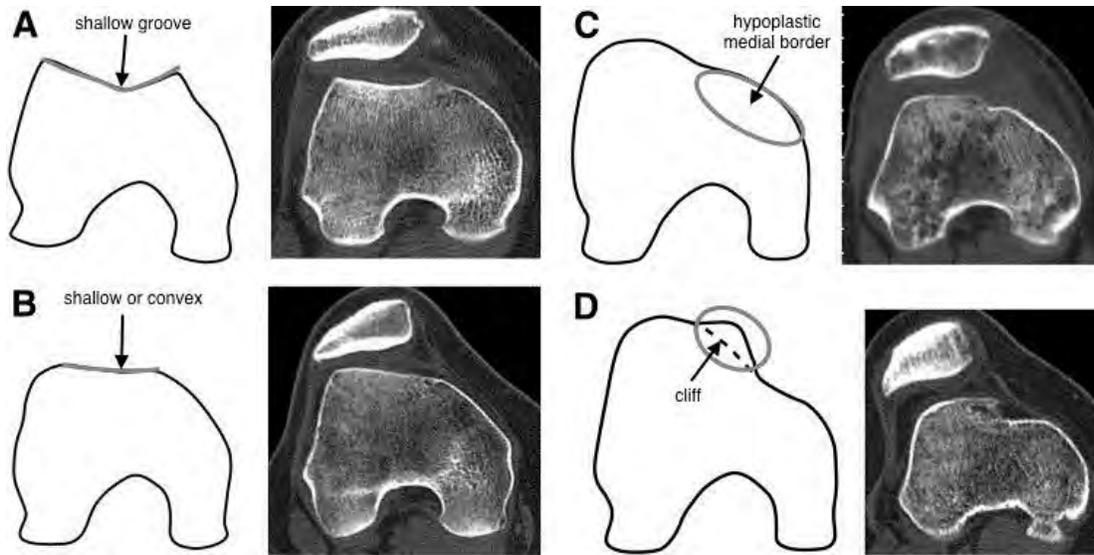


Figure 21: The different grades of Trochlear Dysplasia.³³

When one of the condyles of the PFJ has extreme posture as noted above, the patella becomes susceptible to dislocation due to decreased structural support. In people with trochlear dysplasia, patellar dislocation can result from even a minor force, due to the lack of osseous stabilizing factors. The patella begins contact with the trochlear groove at 30 degrees of flexion³⁴, which is why stabilization is dependent on soft tissue stabilizers within the first 30 degrees. However, the first 40 degrees of flexion are an exceptionally vulnerable position for someone with trochlear dysplasia.³¹ This is because if the trochlear groove has an extreme shape, known as being aplastic, between 30 to 40 degrees of flexion when the patella and trochlear groove would normally be in contact, the patella exhibits poor engagement with the trochlear groove. The contact between the patella and the trochlear groove throughout degrees of flexion can be seen in Figure 22. A shallow trochlear groove results in seating of the trochlear groove at approximately 45 degrees of flexion. This explains why most episodes of dislocation or subluxation in patients with

trochlear dysplasia occur within the first 40 degrees of flexion, before contact between the patella and the femoral groove normalizes.³⁵

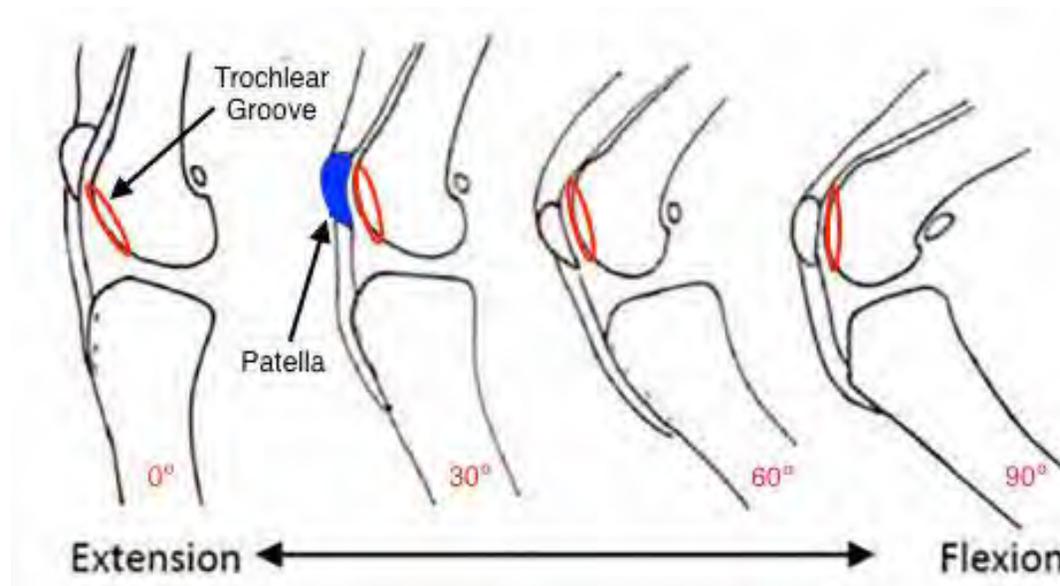


Figure 22: Different degrees of flexion and patellar contact with the trochlear groove.³⁶

Degree of patellar tilt has been identified as a pathological factor that contributes to patellar instability. It refers to the angle of tilt, that the patella exhibits, as seen in Figure 23. Patellar tilt is a type of patellar malalignment and can be used to identify a patient with patellar instability. In a normal patient, the degree of patellar tilt is the same during relaxation (0 degrees) and 15 degrees of flexion. However, in a patient with patellar instability, it has been identified that patellar tilt increases at 15 degrees of flexion as compared to 0 degrees.³⁷ In a patient with patellar tilt, as the patella moves through flexion and extension, force is unevenly placed on the patella due to the abnormal angle which makes the patella vulnerable to luxation. Patellar tilt is measured by calculating the slope of the lateral facet of the patella. The degree of tilt in those identified with patellar

malalignment is 10 degrees or greater, whereas the degree of tilt in normal subjects is 10 degrees or less.³⁸



Figure 23: Measurement of patellar tilt.³⁹

The vastus medialis plays a significant role in stabilization of the PFJ. Dysplasia of this muscle has been shown to be a predisposing factor to PI. In one study dysplasia of the VMO was found to be associated with excessive patellar tilt and subsequent patellar instability. An anatomical difference in the vastus medialis muscle was observed in patients with patellar tilt and PI. Instead of inserting on the medial aspect of the patella, these patients' VMO attachment site was at the quadriceps tendon. As seen in Figure 24, on the left, the VMO inserts into the quadriceps tendon, whereas on the right the VMO inserts on the patella. Insertion on the quadriceps tendon decreases the medial restraint of the patella, decreasing a horizontal pull and increasing a vertical pull on the patella. Without this medial restraint, the power of the vastus lateralis is not counteracted. Therefore the patella follows the lateral pull of the vastus lateralis, which increases lateral migration of the patella, patellar tilt, and subsequent patellar instability.³⁷

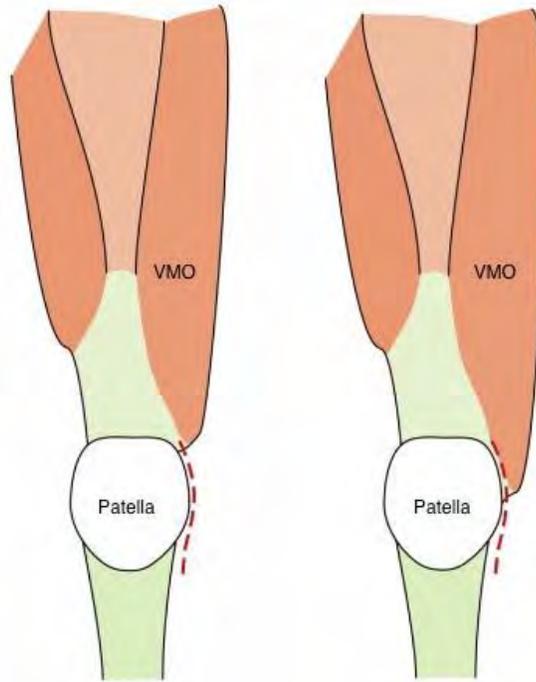


Figure 24: Different anatomical insertion points of the VMO.⁴⁰

Correlations have been found between patellar tilt and patellar shape, both playing a role in the predisposition to patellar instability. The ossification of the patella begins to form between 3 to 6 years old and is completed between ages 13 and 16, typically earlier in girls.⁴¹ During the ossification process, patellar formation can result in a patellar shape that predisposes a person to patellar instability. The three different shapes identified thus far are: Type A, Type B, and Type C. Type A patellar shape means that the medial facet of the patella is concave, but still the same size as the lateral facet. With Type B, the medial facet is concave and smaller than the lateral facet. In Type C, the medial facet is convex, and lies almost vertical as shown in Figure 25. In each patellar shape below note the amount of the patella lateral to the plum line and its relative contribution to the susceptibility of lateral

luxation. Type C has been found to be associated with higher rates of patellar dislocation as compared to other types of patellar shape.³²

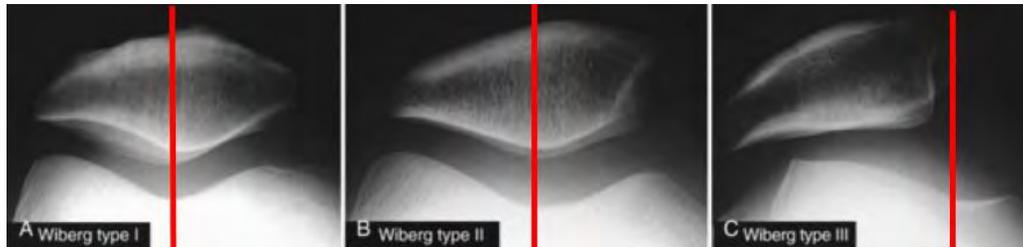


Figure 25: The three types of patellar shape as categorized by Wiberg.⁴²

The influence of hormones on laxity of ligaments remains controversial, but some evidence suggests that fluctuating hormone levels during the menstrual cycle contribute to the higher rates of knee injuries seen in females. Throughout the menstrual cycle estrogen and progesterone levels rise and fall. During ovulation when estrogen levels drop and progesterone levels are rising, maximum-loading tests revealed greater knee laxity.^{43,44} The measurement of knee laxity refers to the looseness of the ligaments, therefore with knee laxity, ligamentous stabilization decreases. During menses, researchers found greater tibial and hip internal rotation, also known as anteversion, as previously discussed. This internal rotation created poor landing techniques in the subjects, which may explain the higher rates of knee injuries, specifically patellar instability, seen in menstruating active females.⁴⁴ However, scholars acknowledge that hormonal research is ongoing.

Treatment

Based on the predisposing factors that a patient might have, different procedures may be necessary to buttress, augment, or alter the muscular angle of pull, patellar collateral

ligaments, or osseous structures of the PFJ. In general, the three techniques for treatment include: conservative treatment, arthroscopic surgery, and invasive surgery.

Conservative treatment should be considered a priority thus forestalling the invasive measures of arthroscopy or surgery.⁴⁵ Conservative treatment consists of physical therapy. Because of the implications that the VMO has on the stabilization of the patella, specific exercises should be administered to address VMO deficits. In a controlled study, subjects who spent more time focusing on VMO strengthening showed greater knee extension strength between 0 and 30 degrees as compared to general quadriceps strengthening.¹⁵ Because there is a lack of osseous stabilization within 0 to 30 degrees, greater muscular stabilization during these degrees of flexion is vitally important. After 6 months, the VMO group showed greater strength in all but 90 degrees as compared to the general quadriceps group. After 12 months, the quadriceps group showed greatest strength at 0 and 90 degrees, while the VMO group showed greatest strength at 30 and 60 degrees. Therefore, a specific training program should involve general quadriceps strengthening, with specific VMO exercises woven into the exercise program.¹⁵

Arthroscopic surgery is an additional method of treatment for patellar instability. With arthroscopic surgery, a patient is less susceptible to the morbidity of an open incision procedure, such as collateral tissue infection. Because of this, arthroscopic surgery has the potential to decrease the postoperative treatment times. In order for a patient to be eligible for arthroscopic treatment, the patient must have tried conservative treatment for at least 6 months, and the patient cannot have significant abnormalities to the PFJ, such as a Q angle greater than 20 degrees, as these extremes of anatomy and posture require a more invasive procedure for correction.²

Invasive surgery is reserved for extreme deficits or postures. Surgeries involve either soft tissue realignment of the proximal knee or osseous realignment of the distal knee.^{46,47} Depending on the predisposition, certain reconstructions may be necessary. Prior to an invasive surgery, MRI should be used in order to assess any rupture of the MPFL.³¹ Within younger populations it is more typical to see MPFL ruptures at the patellar attachment, as where adult populations are more likely to experience ruptures at the femoral attachment. MPFL rupture occurs in approximately 90% of first time dislocation, making this a priority in many invasive procedures.¹⁴

As stated earlier, although MPFL reconstruction may be necessary, osseous morphology should be assessed in unison via MRI. With MRI, if a TT-TG distance greater than 18mm is observed, tibial tuberosity osteotomy must occur in combination with MPFL reconstruction. This osteotomy procedure involves moving the tibial tuberosity medial, which reduces the TT-TG distance, as seen in Figure 26. With a TT-TG above 18mm the patient is at such an increased risk of recurrent luxation, that without osteotomy, MPFL reconstruction will not be successful.^{19,48} Osteotomy procedures can also be used to decrease the Q-angle of a patient, which would reduce the lateral force on the patellar and episodes of patellar instability. This procedure would also be accomplished by osteotomy of the tibial tuberosity resulting in medial repositioning, as seen in Figure 26.⁷ Osteotomy procedures can also be used for patella alta.⁴⁹ This is accomplished via distalization of the tibial tuberosity as seen in Figure 27. With this procedure, the tibial tuberosity is moved inferiorly, which moves the patella distally, reducing patella alta and increasing patella engagement within the trochlear groove.

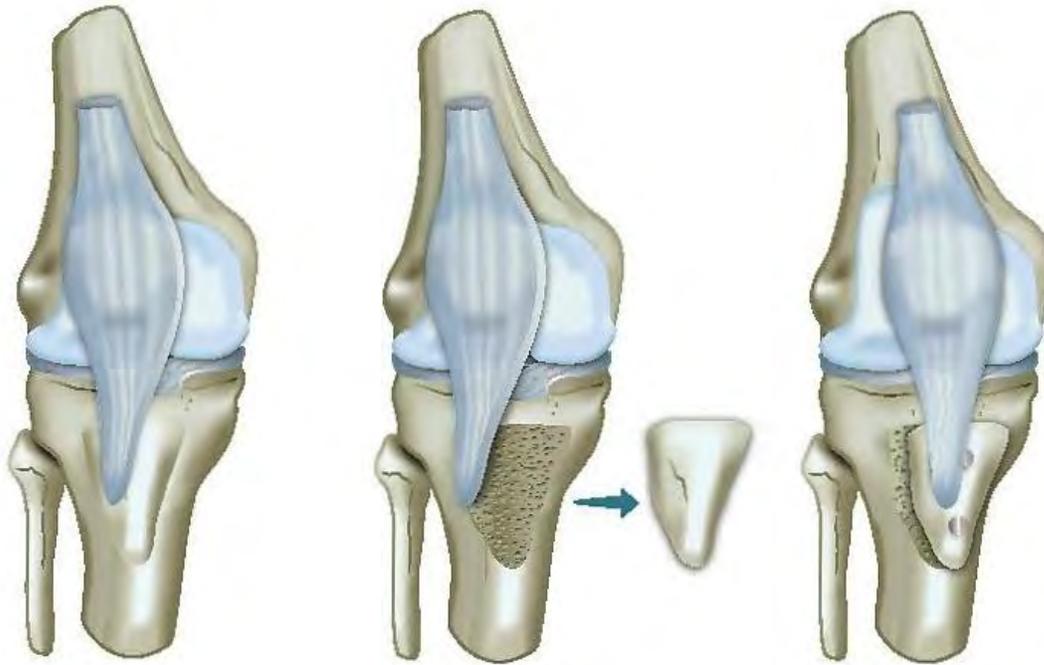


Figure 26: Medialization of the tibial tuberosity for reduction in TT-TG distance or Q angle.⁵⁰

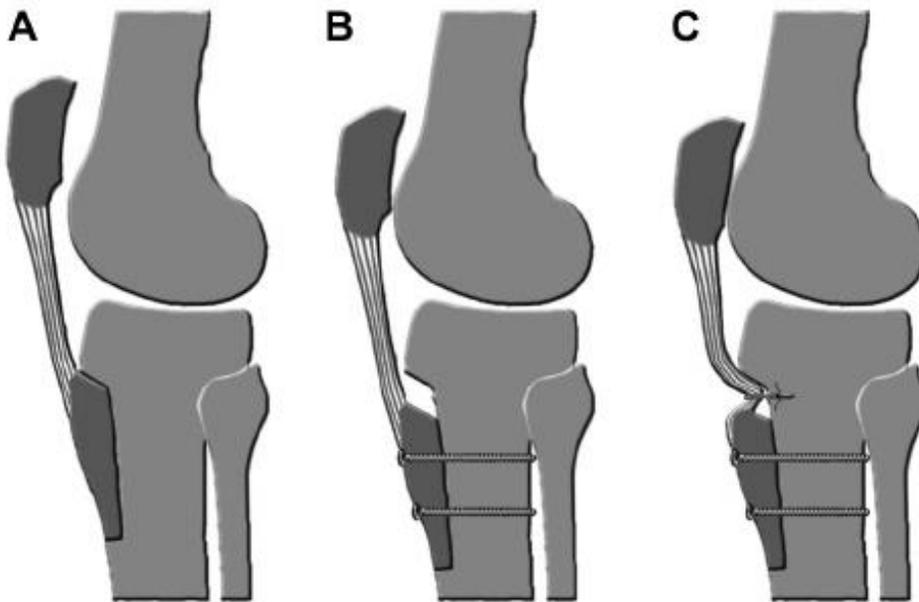


Figure 27: Distalization of the tibial tuberosity for patella alta.⁵¹

If MRI detects trochlear dysplasia, trochleoplasty might be necessary in order to reshape the trochlear groove as seen in Figure 28.³¹ Because trochlear dysplasia is associated with increased rates of recurrent patellar instability, this should be a primary focus of long-term prevention.¹⁴ In failed cases of patellar instability treatment, MRI later discovered that Dejour Type B or Type D trochlear dysplasia was present. Therefore it is important that in treatment of patellar instability, any extreme anatomy of the PFJ is evaluated before treatment is initiated.⁴⁶

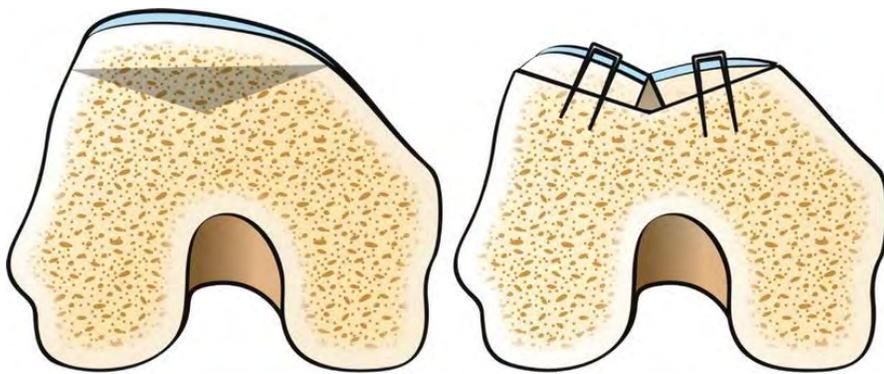


Figure 28: Deepening of the trochlear groove via trochleoplasty.⁵²

Lateral retinaculum release, see Figure 29, has been used to reduce the influence of lateral tracking of the patella. This involves a transecting of the lateral retinaculum, which decreases the lateral pull on the patella. However, recent research has discovered that retinaculum release may not be an effective option for patients with patellar instability. In 50% of subjects, lateral retinaculum release resulted in subsequent medial subluxation of the patella.⁵³

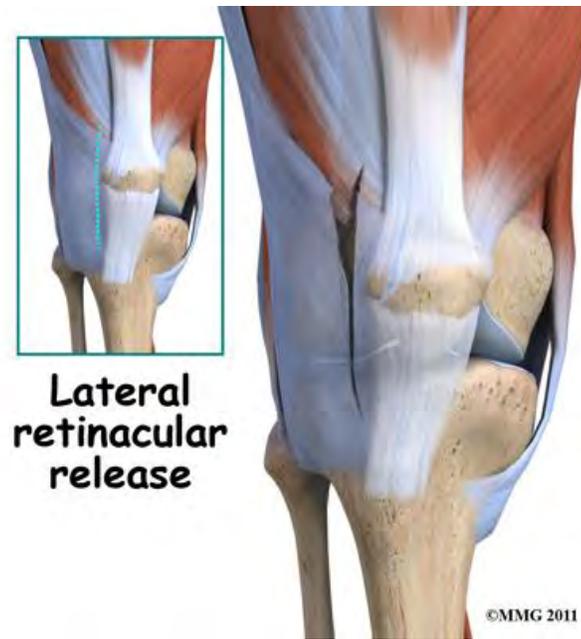


Figure 29: Transecting of the lateral retinaculum for a lateral retinaculum release.⁵⁴

Contraindications

Without treatment, the manifestation of Patellar Instability can lead to osteoarthritis as well as additional episodes of patellar instability. If the patella is not tracking with congruence in the trochlear groove, articular cartilage in the PFJ can deteriorate, leading to osteoarthritis. In fact, osseous morphology is a good indicator of subsequent articular cartilage deterioration.¹⁷

If done correctly, invasive surgeries can have beneficial results. However, if done incorrectly, negative implications can result. As a rule of thumb, it is better to correct within normal range rather than in excess. For instance, if the surgeon overcorrects the tightness of the MPFL, osteoarthritis can occur on the medial epicondyle due to increased medial pull. If the surgeon creates excessive distalization of the tibial tuberosity, patella baja can occur, causing an inferior set patella and subsequent reduced range of motion.¹⁹

Precaution should be given towards invasive surgery in adolescence. If realignment of the tibial tuberosity is performed too early in adolescence, premature fusion of the growth plate can occur which would lead to hyperextension of the knee.²⁴ During MPFL reconstruction, a technique that involves femoral fixation requires MPFL fixation 2.9 to 8.5mm away from the epiphysis. Adolescents who are skeletally immature are put in jeopardy in this procedure because of the risk of disturbing the epiphysis, also known as the growth plate, and causing subsequent growth complications.¹⁶

New research has revealed the benefit of arthroscopic treatment via artificial ligaments, which is still controversial. Some doctors still insist on the use of allografts of the gracilis or the semitendinosus as the gold standard of MPFL reconstruction^{7,35} However, artificial ligaments have the potential to increase stabilization because of the decreased morbidity at the donor site, their similarity to natural ligament structures and biomechanics, the secure fixation in which they offer, and the speed at which they are able to assimilate with the joint. Clinical outcomes of the use of artificial ligaments in patients with patellar instability showed statistically significant improvement ($P < 0.001$) in 98% of the patients. Since the surgical procedure for artificial ligament reconstruction of the MPFL can be performed arthroscopically, it is not as invasive as open surgical techniques. This method of MPFL reconstruction can therefore be more advantageous because it presents reduced postoperative swelling, reduced pain and complications, and decreased recovery times when compared to open surgical techniques.⁵⁵ In a 19-year longitudinal study however, artificial ligaments of polyethylene showed that 27.5% of patients exhibited re-rupture, 29.4% had functional impairment, such as reduced range of motion, and 100% had osteoarthritis.⁵⁵ Because of the long-term implications, the use of artificial ligaments is still being evaluated.

Discussion

With patellar instability a focus should be placed on the biomechanics of every day activities and the susceptibility of the patellar to luxation. A first time dislocation typically requires a traumatic force, either contact or non-contact. However, once this first time luxation occurs, a person is up to 45% more vulnerable to recurrent dislocations, typically within the first 30 degrees of flexion.¹⁵ As mentioned, the MPFL plays a vital role in stabilization in the first 30 degrees. With a recurrent dislocation, the MPFL becomes more laxative, diminishing the ligamentous stabilization during these vulnerable degrees. This leads to susceptibility in daily activities that place force on the patella such as running, climbing stairs, or standing up from a sitting position. As well, in cases of trochlear dysplasia, vulnerability extends to 40 degrees due to poor patellar engagement with the trochlear groove.

Recurrent patellar dislocation is not a random event. Sufferers of patellar instability episodes are usually vulnerable due to a predisposition or. Numerous predispositions have been discussed, particularly osseous, ligamentous, and muscular predispositions. These predispositions make a person vulnerable because they each alter the normal anatomy of the PFJ, requiring less force for luxation of the patella out of the trochlear groove. As well, certain populations, such as females, are more susceptible to PI due to alterations of hormonal or biomechanical structures between genders. The active lifestyle of an adolescent, requiring twisting and cutting motions, places this younger age group at a higher risk of PI.

New research influence conservative and non-conservative treatment options. Once thought to be a solution to patellar instability, contraindications have been found in the

effect of treatment options such as lateral retinaculum release. Because multiple predispositions can accumulate, treatment options need to place importance on not only treating the consequence of luxation, but also treating the underlying cause. The PFJ requires the homeostasis of the muscular, ligamentous, and osseous stabilizers for function without failure.

Conclusion

Patellar instability can be a debilitating pathology. Predispositions make some people so vulnerable that luxation seems unavoidable. However, knowledge of these predispositions help to enlighten the need for muscular stabilization where osseous and ligamentous stabilizers may falter. Health care providers to stay up-to-date on current literature of treatment options to ensure that care is focused on the PFJ as a whole, instead of overcorrection of one predisposition, leading to subsequent negative prognosis. This research project provided a current literature review of the predispositions, treatment options, and prognosis of those you suffer from patellar instability. Hands on cadaveric dissection allowed for research that could be presented with thorough knowledge of normal anatomy of the PFJ, in order to be aware of abnormal and extreme anatomy.

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