Patellofemoral Instability: Evaluation and Management

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Abstract

Patellofemoral disorders are a common cause of knee pain and disability. A thorough history and a careful physical examination are essential to accurate diagnosis, and imaging modalities play an important role. Magnetic resonance imaging can provide information on malalignment and soft-tissue injuries. Although there is a continuum of diagnoses, most patellofemoral disorders can be divided into three distinct categories: soft-tissue abnormalities, patellar instability due to subluxation and dislocation, and patellofemoral arthritis. Many patellofemoral disorders respond to nonoperative therapy. When surgical intervention is necessary, patellar tilt can be successfully treated by a lateral release. Lateral patellar subluxation associated with malalignment can be corrected by a distal realignment procedure such as the anteromedial tibial tubercle transfer. Repair of the medial patellofemoral ligament in cases of patellar dislocation has considerably lowered the incidence of recurrent instability. Although no ideal treatment exists for patellofemoral arthritis, mechanical symptoms may be alleviated by arthroscopic debridement of delamination lesions. Articular cartilage-wear disorders may be stabilized by addressing the primary causative disorder.

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Pain associated with the patellofemoral joint is a malady commonly seen in the orthopaedic office. In the past, anterior knee pain was generically referred to as chondromalacia patella. Chondromalacia, or softening of the articular cartilage, of the patella is a common incidental finding. This terminology should not be used interchangeably with anterior knee pain, but rather should be used to describe a specific pathologic condition. Recent investigations of the anatomy and biomechanics of the patella and peripatellar structures, combined with advances in physical diagnosis and imaging modalities, have led to more accurate diagnoses of patellofemoral pain. This article reviews the most common disorders of the patellofemoral joint: soft-tissue abnormalities, patellar instability, and patellofemoral arthritis (Table 1). Although two or more of these disorders may coexist, classifying them into specific groups is helpful when planning treatment and assessing results.

Anatomy

In 1979 Warren and Marshall[1] delineated the anatomy of the medial aspect of the knee. They described a three-layered system with condensations between tissue planes. The medial patellofemoral ligament (MPFL) was described as being within layer II, superficial to the joint capsule and deep to the vastus medialis. Over the past 5 years, several studies have described the importance of this ligament. In a comprehensive anatomic study of the MPFL, Feller et al[2] found it to be a distinct structure present in all 20 cadavers dissected. The ligament extends from the anterior aspect of the femoral epicondyle to the superomedial margin of the patella (Fig. 1). As the ligament courses anteriorly, its fibers fan out and fuse with the undersurface of the vastus medialis tendon. The size of the ligament varies considerably among individuals, but it is relatively constant

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Table 1
Most Common Disorders of the Patellofemoral Joint

Soft-tissue abnormalities
Patellar tilt
Quadriceps tendinosis
Patellar tendinosis
Osgood-Schlatter disease
Pathologic plica
Reflex sympathetic dystrophy
Patellar instability
Subluxation
Dislocation
Patellofemoral arthritis
Delamination lesion
Degenerative lesion

from side to side within a given person.

The quadriceps functions as a dynamic stabilizer of the patella, while the MPFL acts as a static checkrein to resist lateral translation of the patella. Conlan et al[3] performed a biomechanical study of the relative contributions of the medial soft-tissue restraints in the prevention of lateral displacement of the patella. They found the MPFL to be the major medial soft-tissue stabilizer, providing 53% of the total restraining force. The patellomeniscal ligament and associated retinacular fibers were also found to be important medial stabilizers, contributing an average of 22% of the total restraining force. The remaining transverse fibers of the medial retinaculum (the patellotibial band) and the medial patellotibial ligament were found to be less important restraints to lateral translation of the patella. It is speculated that, in addition to their biomechanical properties, the ligamentous structures provide proprioceptive signals to the surrounding musculature.

History and Differential Diagnosis

A thorough history should focus on the onset and duration of symptoms, the mechanism of injury, and any prior patellar symptoms. All patellofemoral joint disorders may be characterized by peripatellar pain, swelling, crepitus, or instability. Symptoms are occasionally preceded by a traumatic event but more commonly are insidious in onset. The physician should also investigate previous treatment modalities and their success.

Patellar Tilt

Patellar tilt, a common disorder, has been referred to as lateral patellar compression syndrome and excessive lateral pressure syndrome. This condition is characterized by a tight lateral retinaculum, which results in abnormally high forces between the lateral facet of the patella and the lateral trochlea. The onset of symptoms is often insidious and may be associated with minor antecedent trauma. Patients typically present with diffuse anterior knee pain, which is often greatest over the lateral retinaculum during knee flexion. Chronic lateral patellar tilt can lead to degeneration of the articular cartilage of the lateral facet.

Patellar Tendon Rupture and Overuse Syndromes

In addition to patellar tilt, there are several other soft-tissue peripatellar abnormalities. Traction injuries to the extensor mechanism can produce lesions in the quadriceps and patellar tendons. Complete

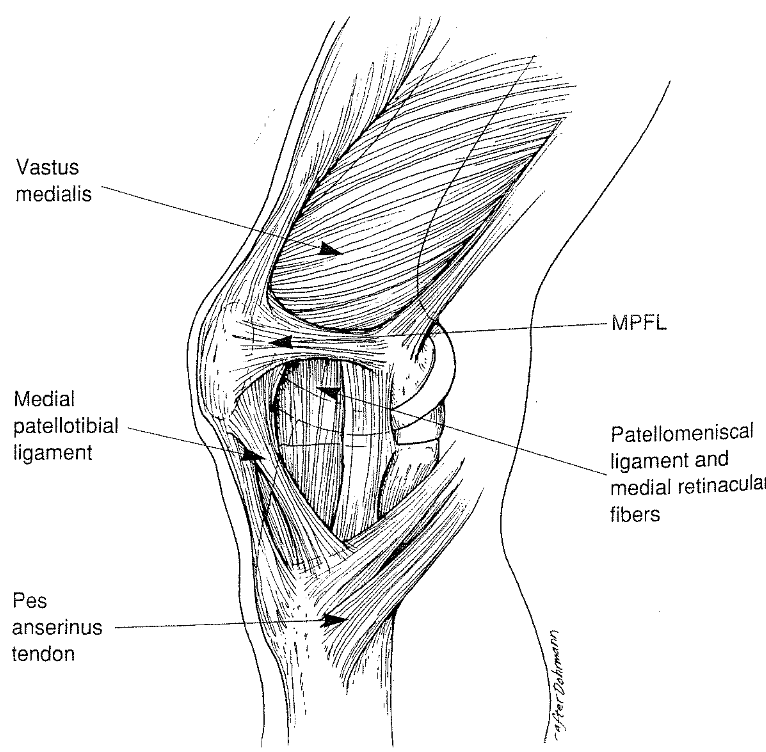


Fig. 1 Anatomy of the medial aspect of the knee. The MPFL provides 53% of the restraining force in preventing lateral displacement of the patella; the patellomeniscal ligament and medial retinacular fibers, on average 22%.[3]

ruptures of the quadriceps tendon typically occur in older persons with preexisting degenerative changes in the tendon. In younger athletes, patellar tendon ruptures usually result from trauma. Overuse injuries to the extensor mechanism are common in athletes who participate in repetitive jumping activities. In skeletally mature individuals, these overload forces may result in quadriceps tendinosis or patellar tendinosis. The lesion in partial rupture of the patellar tendon is typically located in the posterior half of the tendon at its insertion site into the patella. In adolescents, the same forces may produce a traction injury of the tibial tubercle (Osgood-Schlatter disease).

Pathologic Plica and Reflex Sympathetic Dystrophy

Other conditions that may cause anterior knee pain include pathologic plica and reflex sympathetic dystrophy (RSD). Although plicae are usually incidental findings at arthroscopy, they occasionally become thickened and painful. The most common pathologic condition is medial parapatellar plica. The patient may report a snapping sensation as the fibrotic plica rubs against the medial femoral condyle during knee flexion and extension.

When evaluating the patellofemoral joint, RSD should also be part of the differential diagnosis. Pain out of proportion to the initial injury is the classic presentation. The patellofemoral joint is always involved in RSD of the knee. Arthroscopy has been reported to have the potential to exacerbate symptoms of RSD in patients without a mechanical cause of pain.

Patellar Subluxation and Dislocation

Instability disorders of the patella can be classified as either patellar subluxation or patellar dislocation. The patella may articulate abnormally with the femur such that it transiently subluxates either laterally or medially. Lateral translation of the patella is the most common direction of patellar subluxation and is usually associated with malalignment of the lower extremity. In patients with lateral subluxation, the trochlea has a structural role in centralizing the patella during knee flexion. As the knee extends, however, the patella shifts laterally as it disengages from the femoral groove. Patients present with a history of "giving way" as the patella jumps from a centralized position in the trochlear groove to a lateral position with full extension. Lateral subluxation predominantly affects individuals with preexisting malalignment, such as genu valgum or hyperlaxity. Subluxation may also occur after traumatic episodes, such as patellar dislocation.

Medial subluxation is less common and usually iatrogenic. Medial subluxation may occur as a complication of an extensive lateral release, a lateral release performed for an incorrect indication, overtightening of the medial structures, or blunt or surgical trauma resulting in scarring and inferomedial tethering of the patella.

Although medial, superior, and intra-articular dislocations have been described, most patellar dislocations are lateral. Two mechanisms of acute lateral patellar dislocation have been proposed: an indirect injury and a direct blow.[4] The indirect mechanism is more common and involves the combination of a strong quadriceps contraction, a flexed and valgus knee position, and an internally rotated femur on an externally rotated tibia. Patients with dislocations due to an indirect mechanism frequently have one or more predisposing risk factors. An example of this mechanism is a baseball batter who misses while swinging for a pitched ball. On the basis of physical examination with the patient under anesthesia and the location of the bone bruise identified on magnetic resonance (MR) imaging, we hypothesize that the patella dislocates over the terminal sulcus of the lateral femoral condyle with the knee flexed 60 to 70 degrees. Less commonly, lateral dislocations occur after a direct blow to the medial patella.

The patella may spontaneously reduce, or the patient may require a closed reduction by extending the knee while a gentle medial force is applied to the patella. Within hours, the knee joint develops a large hemarthrosis. Ecchymosis occasionally tracks distally along the medial aspect of the leg. Osteochondral fractures of the lateral femoral condyle or the medial facet of the patella have been documented by arthroscopy in 40% to 50% of patellar dislocations.[5-7]

Patellofemoral Degeneration

The articular cartilage of the patellofemoral joint is a frequent site of traumatic and degenerative lesions. The causes of chondral lesions are multiple and include trauma, malalignment, and aging. In athletes who compete in sports that require frequent pivoting and decelerating motions, delamination lesions are common (Fig. 2). These injuries are a result of shear stresses and involve a separation of the noncalcified articular cartilage from the calcified cartilage. The second mechanism of articular-cartilage injury is chronic abrasive wear that causes superficial to deep damage. These injuries should be further classified as being partial- or full-thickness lesions. Abrasive, degenerative changes secondary to malalignment involve primarily the lateral facet.

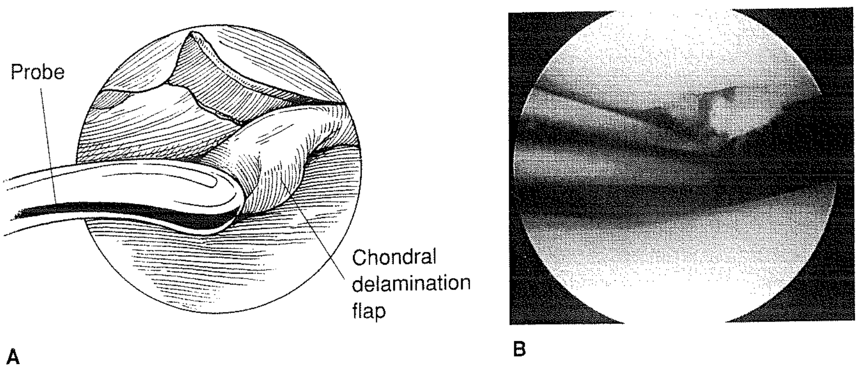


Fig. 2 Drawing **(A)** and athroscopic image **(B)** of a delamination lesion of the articular cartilage of the patella.

Presenting symptoms of articular-surface lesions include anterior knee pain, swelling, and a grinding sensation. There may be either diffuse, nonspecific pain or a sharp, stabbing sensation at a specific angle of knee flexion.

Physical Examination

After the history has been completed, the patient should be assessed for any physical signs that may serve as prognosticators of patellar instability (Table 2). The presence of femoral anteversion, genu valgum, external tibial torsion, and foot pronation can be documented by observing the patient in a standing position and during the gait cycle. Hip muscular strength and joint range of motion are evaluated with the patient in the supine position to exclude referred knee pain originating from hip disorders.

The Q angle (the angle between the quadriceps tendon and the patellar tendon) should be measured with the knee in flexion. Measurements of the Q angle in full extension may be falsely low in patients with patellar subluxation. The angle is recorded by drawing one line from the anterior superior iliac crest to the center of the patella and another line from the center of the patella to the center of the tibial tubercle. Mean Q-angle values approach 10 degrees in men and 15 degrees in women.

Palpation of the patella and related structures should constitute the next stage of the patellofemoral examination. Comparison with the noninjured knee provides a baseline. First, the patella is examined with ballottement from cephalad to caudad to determine whether an effusion exists. The peripatellar soft tissues are then carefully palpated. Tenderness over the medial epicondyle (Bassett's sign) may represent an injury to the MPFL in patients with acute or recurrent patellar dislocations.[8] Pain on palpation of the inferior pole of the patella is often diagnostic of patellar tendinosis. Retinacular tenderness, hypersensitivity to palpation, and decreased patellar mobility may be signs of RSD.

Valgus testing is important in patients with a patellar dislocation because concomitant medial collateral ligament and MPFL injuries can occur. Patellar symptoms may also mask an anterior cruciate ligament insufficiency; therefore, the Lachman and pivot shift tests are necessary to differentiate these conditions. Since posterior cruciate ligament insufficiency has been reported to be associated with patellofemoral arthrosis, the posterior drawer test is also an essential part of a complete examination.

During the next phase of the examination, patellar tilt should be assessed. The examiner attempts to raise the patient's lateral patellar facet away from the lateral femoral trochlea. An inability to raise the lateral facet to the horizontal is suggestive of lateral retinacular tightness and tethering of the lateral patella. Frequently, patients with lateral patellar tilt demonstrate tenderness along the lateral patellar facet secondary to wear of the articular cartilage.

Patellar mobility is evaluated by attempting to displace the patella medially and laterally. Throughout this portion of the examination the knee is placed in full extension. The number of quadrants of medial and lateral glide is recorded as lateral and medial patellar pressure are applied. The amount of patellar glide on the affected side should be compared with that on the asymptomatic side. In a normal knee, the patella cannot be displaced more than half its width in either direction. The knee is then flexed, and the test is repeated while observing the patient for evi-

Table 2
Predisposing Risk Factors for Patellar Instability

Femoral anteversion
Genu valgum
Patellar dysplasia
Femoral dysplasia
Patella alta
Vastus medialis obliquus atrophy
High Q angle
Pes planus
Generalized hyperlaxity

dence of apprehension and reflex quadriceps activation. Reproduction of the patient's dislocation symptoms with applied medial patellar pressure is referred to as the lateral apprehension test.

Patellar tracking is assessed as the patient sits on the edge of the examining table and flexes and extends the symptomatic knee. Normally, the patella is centered within the femoral trochlea with slight knee flexion and traces a straight line as the knee is brought into extension. In patients with patellar subluxation, however, the patella travels from a central position within the femoral trochlea at 30 degrees of flexion to a laterally subluxated position in full extension. The lateral excursion during terminal knee extension, referred to as the J sign, is pathognomonic of lateral patellar subluxation.

As part of the examination, the patient's patella should be palpated for crepitus, which may suggest an articular-cartilage injury. Compression of the patella during full range of motion of the knee may reproduce the associated pain. The location of the chondral injury may be estimated on the basis of the knee-flexion angle in which pain is experienced. Articular lesions on the distal patella are painful during early knee flexion; proximal patellar lesions are manifested with further flexion. Localized tenderness medial to the patella with an associated palpable snap may be indicative of a pathologic plica.

In the last phase of the examination, the patient lies prone with the affected knee hanging over the side of the examining table (Fig. 3). The evaluation is similar to that with the patient supine, but the prone position relaxes the quadriceps and allows an accurate assessment of patellar mobility. In addition, the prone position is ideal for documenting femoral and tibial torsion.

After completion of the physical examination, aspiration of an intra-articular effusion can be extremely helpful in determining the diagnosis and optimal treatment modality. A hemarthrosis implies a traumatic injury, whereas serosangineous fluid may indicate an articular-cartilage lesion. In acute patellar dislocations, it is extremely important to examine the aspirate for the presence of fat droplets, which indicate the presence of an associated osteochondral fragment.

Imaging

The initial radiographic evaluation of the patellofemoral joint should include standard anteroposterior and lateral weight-bearing views as well as an axial radiograph. Plain films are a useful screening tool to rule out gross malalignment and fractures. However, they underestimate the presence of articular-surface lesions. Routine radiographs have been shown to identify fewer than 50% of osteochondral loose bodies. A true lateral standing radiograph may be helpful in assessing patellar alignment on the basis of the rotation of the patella in relation to the femoral condyles.

The lateral view also allows determination of the depth of the femoral trochlea and the height of the patella. Several measurements have been described to measure patella alta. Controversy exists as to which radiographic measurement is most accurate. Clinical examination may be more appropriate to assess the height of the patella. When the patella does not engage in the trochlea by 15 to 20 degrees of knee flexion, patella alta may be present.

The Laurin and Merchant axial radiographs are obtained with the knee flexed 20 and 40 degrees, respectively. However, one tangential

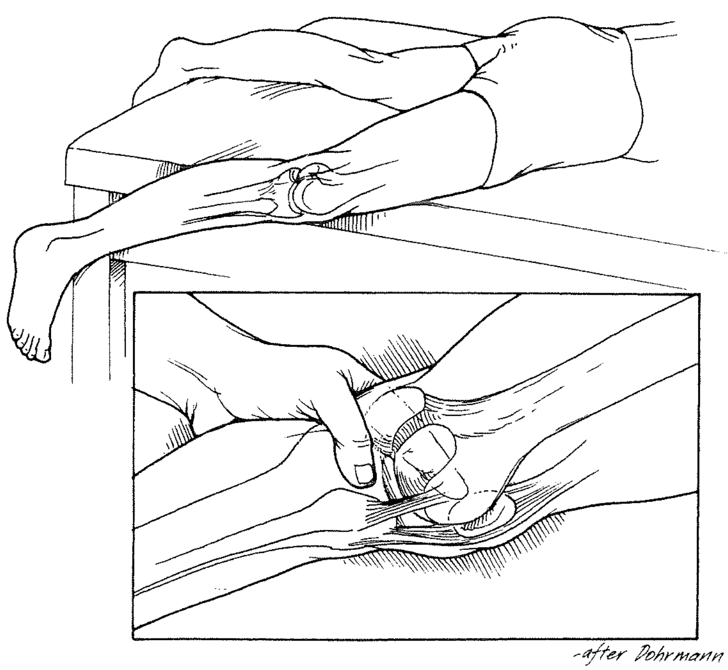


Fig. 3 Examination of the patella with the patient prone.

view with the knee flexed 30 degrees is usually sufficient for assessing patellar tilt, which reduces the amount of radiation exposure. The x-ray beam is projected caudad at an angle of 30 degrees from the plane of the femur.

The axial radiograph is the most helpful plain film for diagnosing patellar tilt. A line is drawn along the lateral facet of the patella, and a second line is drawn across the condyles of the trochlea anteriorly. Normally, the angle between these two lines will be open laterally. If the lines are parallel or the angle opens medially, the patella is probably tilted.[9]

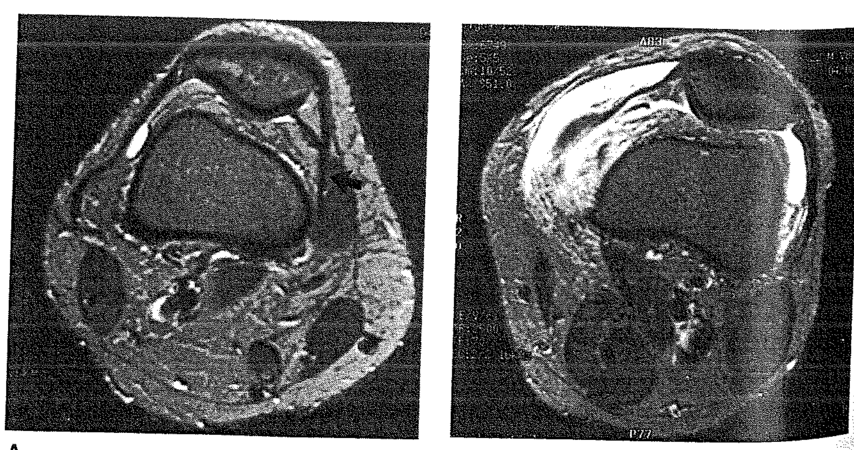
Teitge et al[10] recently described a new radiographic technique that can be a helpful adjunctive test for diagnosing patellar instability. They first obtained bilateral axial radiographs of the patellofemoral joints in anatomic position. A constant medial and lateral force was applied to the patellae with an instrumented device, and axial radiographs were repeated. Teitge et al found that a 4-mm increase in medial or lateral patellar excursion compared with the patellar excursion of the asymptomatic knee correlated with patellar instability.

Stress radiographs are helpful in identifying patients with congruity of the articular surfaces whose knees may subluxate or dislocate because of deficient ligamentous structures. Measurements on stress radiographs are more reliable predictors of lateral, medial, and multidirectional patellar instability than measurements made on static radiographs. Furthermore, they can provide objective information when evaluating the results of different treatment regimens. Patients who are unable to relax the extensor mechanism due to pain or who have bilateral symptoms are not candidates for stress radiography.

Computed tomography (CT) has been shown to be more sensitive than axial radiography in delineating patellar malalignment.[11] Among the advantages of CT over plain radiography are that there is no image overlap or distortion and that there are precise reference points for reliable measurements. Unlike conventional radiography, CT allows axial cuts of the patellofemoral articulation at angles less than 20 degrees of knee flexion. This enhances the detection of subluxation as the patella loses the stabilizing function of the lateral femoral condyle.

Another role for CT is in identifying lateralization of the tibial tubercle, as measured by the distance between the tibial tubercle and the trochlear sulcus. An axial CT image demonstrating the femoral trochlear groove is superimposed on an axial image of the tibial tubercle. A line is drawn on this superimposed image between the posterior margins of the femoral condyles. Two lines are drawn perpendicular to this line, one bisecting the femoral trochlear groove and the other bisecting the anterior tibial tuberosity. The distance between these two lines determines the extent of lateralization of the tibial tubercle. Values greater than 9 mm have been shown to identify patients with patellofemoral malalignment with a specificity of 95% and a sensitivity of 85%.[12]

Magnetic resonance imaging combines the accuracy of osseous measurements made on CT with the ability to visualize the soft tissues. In addition, MR imaging can depict articular-cartilage damage directly for large lesions or indirectly by changes in the underlying bone for smaller lesions. Using MR imaging, Sallay et al[13] were able to visualize the pathoanatomic features of patellar dislocations. They identified the essential lesion of patellar dislocations as being a tear of the MPFL off the femoral insertion (Fig. 4). The location of the injury was confirmed by surgical exploration. Although other authors have identified avulsions of the MPFL off the patella with the use of MR imaging alone, we believe that this is an uncommon location for injury and may be overinterpreted on MR imaging studies of patients



A B

Fig. 4 Axial MR images of a normal MPFL (**A**) and an avulsion of the MPFL off the medial femoral epicondyle (**B**).

with an osteochondral lesion on the medial facet of the patella.

Sallay et al[13] used MR imaging to detect several other injuries after a patellar dislocation: an effusion in all 23 patients studied, increased signal intensity and retraction of the vastus medialis muscle in 18 (78%), a bone bruise in the lateral femoral condyle in 20 (87%), and a bone bruise in the medial patella in 7 (30%). The authors also noted that the location of the bone bruise on the lateral femoral condyle was slightly anterior and superior to the typical bone bruise seen after an acute anterior cruciate ligament injury.

Nonoperative Treatment

Historically, nonoperative treatment has been the mainstay of therapy for patellofemoral disorders. As an important adjuvant in the development of a treatment plan for patellofemoral pain, objective isokinetic strength testing can provide valuable information. By evaluating a printout of a concentric quadriceps strength test, the physician can assess any deficits that correlate with a painful arc of knee motion (Fig. 5). Armed with these objective data, the physician and the therapist can design a knee-strengthening program to avoid painful range of motion.

The primary goal in patellofemoral rehabilitation is to decrease symptoms, increase quadriceps endurance and strength, and return the individual to maximum function. To improve quadriceps strength, gravity and active resistive exercises are emphasized. Biomechanical analysis has shown that patellofemoral contact pressures are lowest from 0 to 30 degrees of knee flexion. Therefore, short-arc quadriceps extensions in this range of motion are recommended to strengthen the extensor mechanism. Isotonic quadriceps exercises have been shown to be more beneficial than isometric exercises. Although some authors have noted decreased patellofemoral contact forces with closed-chain quadriceps exercises from 30 to 60 degrees of knee flexion, it still remains unclear whether closed- or open-chain kinetic exercises are preferable for patellofemoral rehabilitation. Thus, short-arc, isotonic, closed- or open-chain quadriceps-strengthening exercises are recommended in the early stages of patellofemoral rehabilitation for patients treated nonoperatively and for those treated by surgical repair. Isokinetic, eccentric, and high-torque exercises can cause high articular-cartilage pressures and should be avoided.

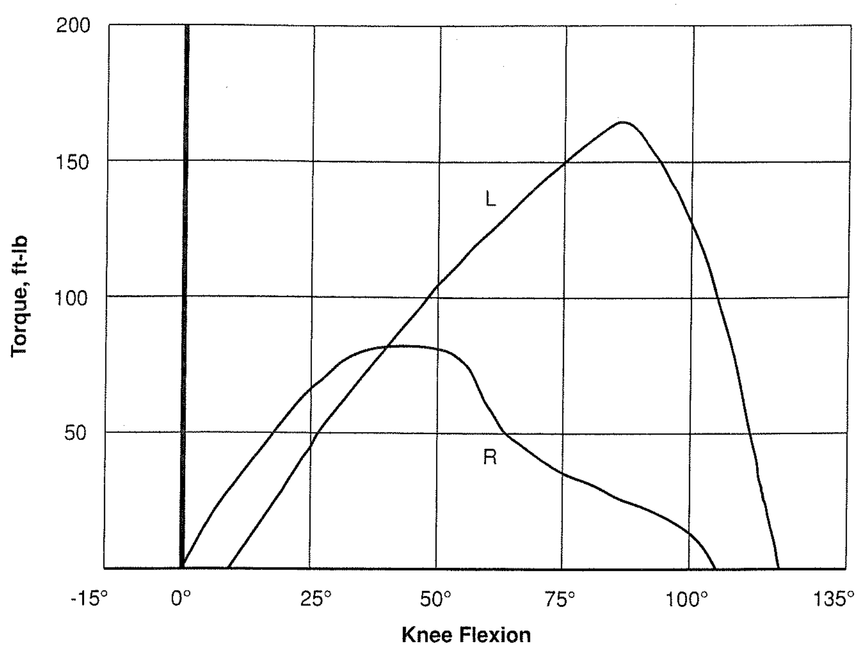


Fig. 5 Isokinetic torque curves of quadriceps muscle. Note the sharp decline in extensor strength of the affected right leg (R) at 50 degrees of knee flexion compared with the normal left leg (L). At surgery, a delamination lesion of the patellar articular cartilage was identified; the lesion contacted the trochlea at 50 degrees of knee flexion.

Patellofemoral instability symptoms may be reduced in some patients with a patellar cutout brace or patellar taping. Although patellar taping was originally reported to have a high success rate, researchers have been unable to reproduce these results in recent studies.[14] Therefore, patellar bracing and/or taping should be regarded as adjuvants to the mainstay of patellofemoral rehabilitation, quadriceps strengthening.

There currently exists a debate in the orthopaedic literature regarding nonoperative versus operative treatment of acute patellar dislocations. Some authors recommend immediate repair of the injured medial structures; others have suggested a more conservative approach. When nonoperative therapy is chosen, the treatment regimen should include early reduction of inflammation and swelling. This can be accomplished by aspiration of the knee joint and immobilization close to full extension with a lateral patellar pad to reapproximate the torn medial structures. After a short period of immobilization, protected range-of-motion exercise in a patella-stabilizing brace is emphasized. The next phase of rehabilitation should concentrate on quadriceps-strengthening exercises. Aquatic therapy and vastus medialis obliquus strengthening have been found to be particularly helpful techniques. The last phase of rehabilitation involves enhancing patient proprioceptive feedback, as well as developing sport-specific skills. Scientific studies documenting the cost-effectiveness of these physical therapy modalities are lacking in the literature.

Surgical Treatment

Arthroscopy

The arthroscopic evaluation of the knee with patellofemoral symptoms involves a systematic survey of the entire knee joint. Examination of the patellofemoral joint begins with inspection of the articular surfaces of the patella and femoral trochlea. The extent and type of chondral lesion are evaluated by probing the articular surface. Arthroscopy can accurately distinguish between delamination injuries and abrasion injuries. Arthroscopy cannot be used to identify injury to the MPFL because that structure is extra-articular.

The superomedial portal is particularly useful in evaluating patellar tracking and patellar tilt.[15] The lateral facet should align with the trochlea by 20 to 25 degrees of knee flexion and the midpatellar ridge by 35 to 40 degrees of knee flexion. Any lateral overhang of the patella should be documented while the patella is engaging the femoral trochlea. Evidence of patellar tilt should also be noted. After observing passive patellar tracking, a muscle stimulator can be applied to the quadriceps to evaluate active patellar tracking. The arthroscope can be reinserted into the joint after an open patellar realignment to assess tracking. Adjustments in the alignment can be made accordingly.

An alternative to arthroscopy with a liquid medium is CO_2 arthroscopy.[16] This technique provides a clearer visual field, precludes motion of tissue in the arthroscopic field, and allows assessment of patellofemoral alignment. The senior author (J.A.F.) believes that CO_2 arthroscopy also allows accurate evaluation of crepitus by depicting any points of increased friction. The disadvantages of CO_2 arthroscopy include the greater cost of the equipment and the risk of subcutaneous emphysema, which can be prevented by using a tourniquet. When arthroscopy is performed with the use of local anesthesia, it may be necessary to flush the knee with liquid after 30 minutes to avoid knee discomfort from distension of the joint with the CO_2 gas.

Patellar Tilt

The treatment of choice for patellar tilt after an unsuccessful trial of nonoperative therapy is an arthroscopic lateral release. This procedure has been shown to be most effective in patients with patellar tilt.[17] The lateral release does not substantially reduce the active lateral vector of the quadriceps and therefore has less satisfactory results in patients with subluxation. The entire lateral retinaculum, vastus lateralis obliquus, and distal patellotibial band should be released.[18,19] The release is performed 5 mm lateral to the lateral patellar border, covering the distance from 1 cm superior to the patella to the anterolateral portal.

Although a lateral release is a routine technical operation, the procedure may be associated with several potential complications. Hemarthrosis, the most common postoperative complication, inhibits the quadriceps and delays rehabilitation. The frequency of postoperative hemarthrosis due to injury to the superior lateral geniculate artery can be diminished by performing the release with electrocautery. In addition, the tourniquet should be deflated before closure to cauterize any bleeding vessels. Incising the vastus lateralis tendon or performing a lateral release on patients with a disorder other than patellar tilt may lead to medial patellar subluxation. Release of the main vastus lateralis tendon should not be performed; otherwise, the muscle may retract and atrophy, leading to imbalance of the patellar stabilizers. This can be avoided by angling the release 45 degrees in a lateral direction proximal to the superior margin of the patella.

Subluxation

Surgery may be indicated in patients with subluxation if symptoms persist after an extensive nonoperative program (Fig. 6). The optimal surgical procedure is determined by the type of subluxation. For most patients with subluxation secondary to malalignment, a distal realignment procedure produces a good outcome. The primary goal of the procedure is to transfer the tibial tubercle medially to correct the Q angle or the tubercle-sulcus angle. Results with a direct medial transfer of the tibial tubercle (the Hauser procedure) have been disappoint-

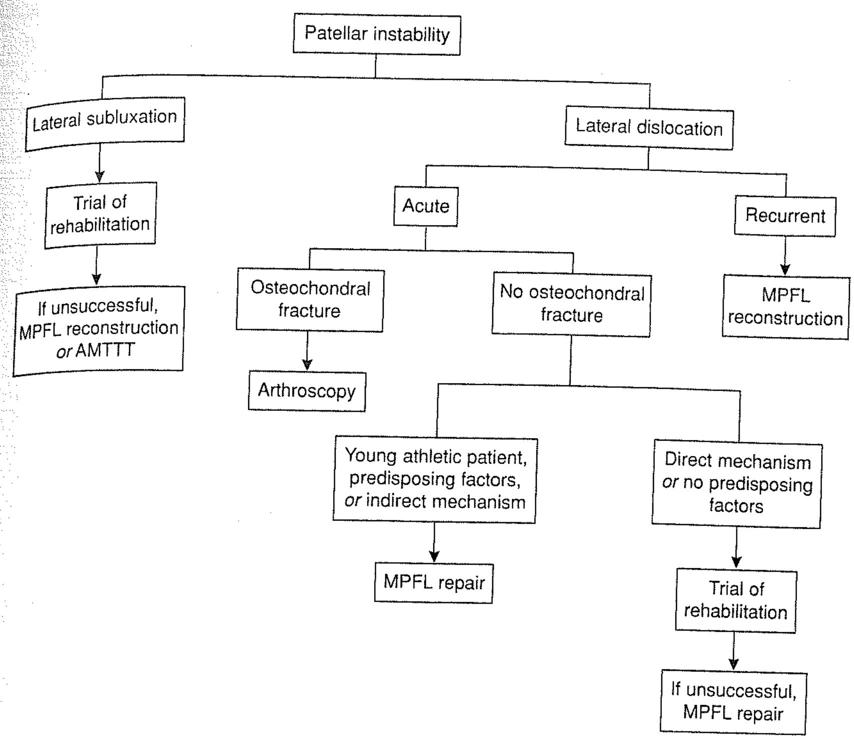


Fig. 6 Algorithm for evaluation of patellar instability. AMTTT = anteromedial tibial tubercle transfer.

ing due to posteriorization of the tubercle as it is moved medially down the slope of the tibial tubercle. This increases the patellofemoral contact forces and can predispose to degenerative changes. Instead, an anteromedial transfer of the tibial tubercle is recommended.[20,21] This procedure corrects the Q angle with medialization of the tibial tubercle and unloads the patellofemoral articulation with anteriorization of the tibial tubercle. A hinge of bone is maintained intact at the distal tubercle to facilitate healing. After the tibial tubercle has been transferred anteriorly and medially, the bone pedicle is locked into position with two cortical screws.

In skeletally immature patients with subluxation, transfer of the tibial tubercle should be avoided until closure of the proximal tibial growth plates. Nonoperative therapy before skeletal maturity should include exercises to strengthen the vastus medialis obliquus, use of a patellar stabilizing brace, and restriction from provocative activities. For the subgroup of patients with normal patellar alignment who have subluxation secondary to trauma, a proximal repair or reconstruction of the medial structures may be more appropriate.

Dislocation

The natural history of untreated patellar dislocation has been reported in several studies. Hawkins et al[6] reported redislocation rates of approximately 15% in their series of patients who were immobilized for 3 weeks after injury. Cofield and Bryan[22] studied 48 conservatively treated patellar dislocations and noted a substantially higher redislocation rate (44%), with 52% of the results being classified as failures. Hughston and Deese[23] reported a redislocation rate of 20% to 43% in patients with first-time patellar dislocations treated conservatively. Therefore, in patients treated nonoperatively for an initial episode of patellar dislocation, the chance of recurrent dislocation ranges from approximately 15% to 44%.

Osteochondral lesions, which may be detected by the presence of fat droplets in the knee aspirate, are common after an acute patellar dislocation and should be evaluated through the arthroscope (Fig. 6). Large articular lesions are optimally fixed acutely; small fragments are removed.

Management of patellar instability due to an acute patellar dislocation is controversial. Advances in the understanding of the pathoanatomy of acute patellar dislocation combined with the high incidence of recurrent patellar redislocation have led to a renewed interest in acute surgical repair. Candidates for surgical repair of the MPFL include young athletic patients who sustained the dislocation by an indirect mechanism. The operative procedure is performed through a 4-cm incision just anterior to the medial epicondyle at the distal edge of the vastus medialis obliquus muscle belly. The MPFL is identified deep to the fascial layer of that muscle (Fig. 7). Most injuries to the MPFL are avulsions off the femur and may be repaired directly to the bone with suture anchors. We do not routinely perform a lateral release or anteromedial tibial tubercle transfer with this procedure. In patients who had symptoms of patellar tilt before the acute dislocation as well as intraoperatively confirmed patellar tilt after MPFL repair, a lateral release may be required.

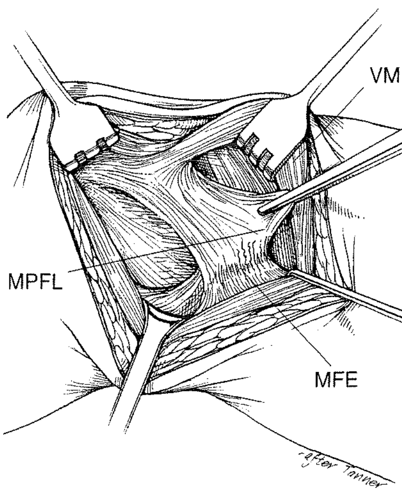


Fig. 7 Intraoperative dissection of the MPFL. MFE = medial femoral epicondyle; VM = vastus medialis.

Similarly, for patients with anatomic malalignment and a history of patellofemoral subluxation before the acute dislocation, a realignment procedure may be necessary in addition to the MPFL repair.

The short-term results of surgical repair include redislocation rates of less than 10%.[13,24] Although the incidence of instability is markedly reduced with operative repair, many patients continue to report pain and swelling. These persistent symptoms are most likely secondary to articular-cartilage lesions from the original injury.[25] Surgery is accepted as the treatment of choice for recurrent patellar dislocations, although there are no prospective studies that document the optimal procedure. Arthroscopy combined with a repair of the essential lesion to the MPFL may provide the best outcome.

Arthrosis

Management of patellofemoral arthritis refractory to conservative measures is based on the patient's age, activity level, extent and location of cartilage damage, and patellofemoral mechanics. In athletic patients with traumatic delamination lesions, the damaged articular cartilage may be arthroscopically debrided to a stable margin. The prognosis is more favorable for lesions smaller than 1.5 cm. Subchondral drilling is controversial, and its use is dependent on the discretion and experience of the surgeon. Return to sports may be allowed as early as 2 to 3 months postoperatively, although maximum resolution of symptoms is usually not achieved for 6 months.

In patients with degenerative, abrasive changes of the articular cartilage, the underlying cause of the abnormal forces on the patella should be identified and corrected. Lateral-facet arthrosis is common in patients with long-standing patellar tilt or subluxation. A lateral release may help relieve arthritic symptoms in patients with patellar tilt and secondary arthrosis.

In patients in whom subluxation results in lateral-facet arthrosis, anteromedial tibial tubercle transfer may ameliorate both maladies. Anterior displacement of the tibial tubercle unloads the distal and lateral facets of the patella and shifts the forces to the proximal and medial facet of the patella. If a steep oblique osteotomy is used, up to 17 mm of tibial tubercle anteriorization can be achieved without requiring any bone graft. The best results are obtained in patients with some preservation of the articular cartilage proximally and medially. Concomitant medial transfer of the tibial tubercle improves the Q angle, thereby eliminating subluxation. The angle of the osteotomy can be adjusted to create more anteriorization or medialization. Although complications have been less common and less severe after anteromedial tibial tubercle transfer than after other distal realignment procedures, the risks of skin slough, infection, and compartment syndrome still exist.

Summary

Disorders of the patellofemoral joint are a common source of knee pain. The wide spectrum of pathologic conditions can be broadly classified as soft-tissue abnormalities, patellar instability, and patellofemoral arthritis. A complete history and physical examination with selective imaging studies should lead to an accurate diagnosis. For many disorders, a trial of nonoperative treatment often provides good results. When indicated, surgical treatment can yield substantial improvement in symptoms and patient satisfaction.

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