Rehabilitation and Nonoperative Treatment of Patellar Instability

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Abstract: Patellofemoral instability can be a difficult condition for clinicians to manage. Differentiation needs to be made as to whether the problem is an acute injury where a traumatic incident has usually precipitated the dislocation or whether the problem is a recurrent instability where the patellofemoral joint is unstable during everyday activities. This review defines instability, discusses the factors affecting instability, and provides assessment procedures and nonoperative intervention strategies for the clinician.

Key Words: patellar instability, rehabilitation, nonoperative treatment

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Patellofemoral instability can be a difficult condition for clinicians to manage. Differentiation needs to be made as to whether the problem is an acute injury where a traumatic incident has usually precipitated the dislocation or whether the problem is a recurrent instability where the patellofemoral joint is unstable during everyday activities. This chapter defines instability, discusses the factors affecting instability, and provides assessment procedures and nonoperative intervention strategies for the clinician.

DEFINITION OF STABILITY/INSTABILITY

Instability is defined as the inability to maintain the distal bone centered within the confines of the proximal bone to allow pain-free and optimal function, so as far as the patellofemoral joint is concerned, this means the inability of the patella to stay within the confines of the trochlea from 20 degrees of knee flexion. Thus, stability of a joint involves the bony architecture, the integrity of the neighboring soft tissues, and the interplay of the surrounding muscles. The most vulnerable position for a joint is the neutral zone where little resistance is offered by the passive structures,[1] which for the patellofemoral joint is the first 30 degrees of flexion before the patella is fully engaged in the trochlea. If decreased passive stability occurs, the neuromuscular system can compensate by providing dynamic stability to the joint. Cholewicki et al[2] found that muscle activity of as little as 1% to 3% can increase the stability around the neutral zone of the spine. Conversely, decreased muscle activation has a detrimental effect on joint stability. A 50% decrease in the medial quadriceps [vastus medialis oblique (VMO)] tension results in a 5 mm lateral displacement of the patella.[3] If the VMO is deactivated or the tension in the vastus lateralis (VL) is twice that of the VMO, then the pressure zone is almost entirely on the lateral facet. Therefore, uncompensated passive insufficiency will ultimately cause pathology and symptoms.[1]

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FACTORS INFLUENCING THE PASSIVE STABILITY OF THE PATELLOFEMORAL JOINT

Femur

The Shape of the Trochlea

The lateral aspect of the femoral trochlea extends further anteriorly than the medial aspect, providing inherent stability once the patella is within the confines of the trochlea (from 20 to 30-degree knee flexion).[4] In a recent study on fresh frozen cadavers, Amis and colleagues found that abnormal trochlear geometry reduced the lateral stability of the patella by 70% at 30-degree flexion. Trochlear dysplasia, which is a combination of decreased trochlear depth with a low lateral femoral condyle, is seen as an important risk factor for patellar instability as the patella cannot engage properly in the trochlea.[5] The incidence of trochlear dysplasia in patellofemoral pain (PFP) sufferers reported in the literature ranges from 0.7% to 2%.[6,7]

Femoral Anteversion

Femoral anteversion is associated with numerous abnormalities in the spine and lower limb including spondylolisthesis, acetabular labral tears, and patellofemoral instability.[8–10] Femoral anteversion alters the position of the femur relative to the patella such that the patella starts in a relatively more laterally displaced position. The amount of anteversion can be estimated clinically by examining hip rotation range and also measuring the Q angle. The Q angle, which represents the line of pull of the rectus femoris muscle, is influenced by both femoral and tibial positions, where external tibial torsion and/or lateral displacement of the tibial tubercle also increases the Q angle. A Q angle of > 20 degrees, which is more common in females, is associated with patellofemoral instability. Often individuals with an increased Q angle have "squinting" patellae and slight tibial vara because knee motion is occurring about a medially rotated axis.

The Patella

The Shape and Size of the Patella

The patella is a sesamoid bone located within the patellar ligament. Its posterior surface has 5 facets, which articulate with the femur: superior, inferior, medial, lateral, and odd. The geometry of the articular facets of the patella varies among individuals and may affect patellar tracking.[11–13] The inferior part of the posterior surface, representing 25% of the patellar height, does not articulate with the femur but lies in close relationship to the highly nociceptive infrapatellar fat pad.[14–16] The lateral facet is almost flat and lies at an angle of approximately 130 degrees to the medial facet so it fits well with the lateral femoral condyle.[17] It is usually longer and broader than the medial facet. Radiographic and cadaveric studies have classified patellae into 4 types on the basis of the size and shape of the medial and lateral facets.[18,19] Type II is the most common patella shape whereas type III is the least common. Type III and type IV tend to be unstable so are more likely to dislocate.[20]

The Position of the Patella

The relationship between patella height and patella tendon length can determine how the patella seats in the trochlea. If an individual has a high sitting patella (patella alta), the patella will be unstable as the patella will not engage well in the trochlea.[21,22] Patella alta is more common in females.

The Noncontractile Soft Tissue Structures

In the first 20 degree of knee flexion, there is no bony support for the patella, so passive stability is provided by the medial and lateral retinaculum and the joint capsule. Anteriorly, the capsule is very thin and loose to accommodate the large range of normal flexion. It stretches medially to laterally across the anterior surface to contribute to the patellar retinaculum.[23] Proximal excursion of the patella from the tibia is limited inferiorly by tension in the patellar tendon. The peripatellar retinaculum interdigitates with the tendon medially and laterally.[14]

The lateral side of the knee is made up of various fibrous layers, forming the superficial and deep lateral retinaculum. The anterior portion of the superficial layer of the lateral retinaculum consists of the fibrous expansion of the VL, running longitudinally along the lateral border and inserting into the patellar tendon.[23] Fibers from the iliotibial band interdigitate with fibers from the VL and the patellar tendon to form the superficial oblique retinaculum.[14]

The deep layer, or deep transverse retinaculum, consists of 3 major components: the epicondylopatellar band (lateral patellofemoral ligament), which provides superolateral static support for the patella; the midportion, which is the primary support structure for the lateral patella, courses directly from the iliotibial band to the patella; and the patellotibial band which provides inferolateral stability for the patella.[14] As most of the lateral retinaculum arises from the iliotibial band, tightness of the band which has its greatest influence at 20 degrees of knee flexion, will contribute to lateral tracking and tilt of the patella. The retinacular support is stronger on the lateral side than it is on the medial side.

The medial retinaculum is thinner than the lateral retinaculum, and was thought to play a lesser role in influencing patellar position or tracking. However, a recent study on 8 cadaveric knees found that a ruptured medial retinaculum caused 49% reduction in lateral stability at 0-degree flexion.[24] Three ligaments, the patellofemoral, patellomeniscal, and patellotibial, lie beneath the retinaculum and are palpable thickenings in the joint capsule.[23,25] The medial patellofemoral ligament (MPFL) forms the primary restraint to lateral patellar translation, particularly at full extension, whereas the medial patellomeniscal and patellotibial ligaments are thought to be less important.[26–29] The MPFL is approximately 55 mm long, and is reported to range from 3 to 30 mm in width, but although it is quite thin it has a tensile strength of 209 N. The distal part of the VM obliquus overlays MPFL where its fibers merge deep into the muscle. The medial and lateral retinacula are therefore affected by the active stabilizers; whereby not only the MPFL merges with the VMO but a large proportion of the lateral retinaculum arises from the iliotibial band which provides both active, through the tensor fascia latae and gluteus maximus origins, and passive stabilization of the patella.[29]

The anterior soft tissues around the hip can contribute to increasing the internal rotation of the hip, which can adversely affect the stability of the patellofemoral joint. These structures include the anterior hip joint capsule, iliofemoral and pubofemoral ligaments, tendons of tensor fascia latae, rectus femoris, psoas and adductor muscles.

FACTORS INFLUENCING THE ACTIVE STABILIZATION OF THE JOINT

The Proximal Muscles

The control of the proximal segment—the thigh by the pelvic muscles is critical to minimize increases in the dynamic Q angle and the valgus vector force on the patellofemoral joint. Acute patellofemoral dislocation usually occurs when the femur internally rotates on a fixed externally rotated tibia. A recent study has shown that subjects with PFP have a delayed onset of gluteus medius relative to control subjects.[30] Strength of the gluteal muscles is also decreased in patellofemoral sufferers where hip abductor and external rotator strength is 26% to 36% lower in females with PFP than age and activity matched controls.[31]

The Distal Muscles

A great deal of medial patellar stability is obtained actively through the muscular attachment of the medial quadriceps, the VM into the patella, which opposes the lateral vector force of the VL, allowing a more efficient extensor moment at the knee. The VM is commonly divided into the oblique portion, the VMO, and the more vertical component, the VM longus (VML).[32–36] Although there is often difficulty accurately distinguishing the VMO and VML as separate entities, most authors agree that they act as 2 distinct functional units owing to their fiber orientation and attachments, and thus angle of force on the patella. The VMO is more obliquely aligned than the VML or VL, thus providing a mechanical advantage to promote a medial stabilizing force to the patella.

In a recent cadaver study, Senavongse and Amis[24] found that relaxation of VMO caused a 30% reduction in lateral stability of the patella. This is supported by studies of muscle fiber type, which indicate that VM functions more as a stabilizer than the VL. The mechanical advantage gained by the fiber orientation is required to counter the relatively larger cross-sectional area and thus force producing capacity of the VL. Although the VMO does not extend the knee, it is active throughout knee extension to keep the patella centered in the trochlea of the femur, thus enhancing VL efficiency during knee extension.[33,37,38] This synergistic relationship between the medial and lateral vastii, which seems to be important in maintaining the alignment of the patella within the femoral trochlea is supported by electromyographic (EMG) studies. Consistently, studies have demonstrated that the EMG activity of VMO and VL in the normal population is relatively balanced in terms of activation magnitude and timing in a wide variety of static, dynamic, weight-bearing, and non–weight-bearing activities[39,40–44] However, individuals with patellofemoral symptoms have a delay in onset timing of the VMO relative to the VL which can be altered positively by physical therapy intervention.[45]

Neural Control

The influence of pain on longer loop pathways and the role of the central nervous system on the motor control of joints have only recently been investigated. Studies in low back pain patients have demonstrated delay in the stabilizing muscles relative to the prime movers during rapid arm movements, whereas in control subjects the stabilizing muscles actually precede the prime movers, giving some insight into the effect of pain on the stabilization of a spinal segment.[46] Similar results have been found with PFP subjects. Individuals with PFP demonstrated a delay in the VMO not only relative to the VL but also relative to the prime mover (tibialis anterior and soleus, respectively) following postural perturbation where they were required to rock back on their heels or up on their toes in response to a light stimulus, whereas the VMO in controls preceded the prime mover and was activated with the VL.[40] This feed-forward strategy used by the central nervous system to control the patella can be restored by physical therapy rehabilitation strategies directed at altering muscle recruitment in functional movements.[45]

Motor control dysfunction being a factor in PFP and instability has further been confirmed by Mellor and Hodges.[47] They found that synchronization of motor unit action potentials was reduced in PFP subjects (38%) compared with controls (90%), which has implications for the selection of rehabilitation strategies.[48]

TYPES OF INSTABILITY

There are 2 major types of instability.

(i) Dislocation that occurs when the distal bone is disrupted and remains past the confines of the proximal bone requiring an external force to relocate it.
(ii) Subluxation that occurs when the distal bone is displaced past the normal confines of the proximal bone but actively relocates during movement.

EXAMINATION

Patellofemoral instability can occur as a first time acute dislocation/subluxation where the most commonly reported mechanism of injury is when the individual has propped and turned inwards on fixed foot (ie, the femur internally rotates on a fixed externally rotated tibia), disrupting the medial soft tissue structures or it can be a recurrent problem where the patella is hypermobile with increased joint laxity. A thorough history is essential to determine the factors involved. The mechanism of injury for the acute patellar dislocation can often be similar to the acute anterior cruciate ligament injury, which needs to be excluded as a differential diagnosis during the examination, as the management for each injury is quite different. A radiologic examination (x-ray) is necessary to exclude an osteochondral fracture, which can be a common feature of acute patellar dislocation. Magnetic resonance imaging reveals fat pad impingement and also ligamentous and capsular disruption after patellar dislocation.[49]

Individuals with recurrent patellofemoral instability complain of a sensation of giving way with certain movements, often twisting and stair ascent and descent. They exhibit apprehension and sometimes pain on lateral movement of their patella. The apprehension sign confirms the diagnosis. The patella is hypermobile and there is often a family history of instability and generalized ligamentous laxity.[50] If the patella is very unstable, that is it subluxes with most knee flexion activities there is usually very little pain, but if the patella only subluxes occasionally under load then the patient will complain of acute, quite severe antero-medial pain and will have difficulty weight-bearing on the limb.

The fat pad is often inflamed as these individuals stand with knee hyperextension and femoral internal rotation. The VMO is often poorly developed and has a vertical attachment point into the patella. The patella is often small and sits high. The stance phase of gait is altered in 1 of 2 ways to minimize the occurrence of subluxation.

(i) Knee flexion is restricted so the knee is extended for the whole stance phase.
(ii) Knee extension is limited so the knee is flexed more than 20 degrees during stance.

Negotiating stairs results in avoidance in using that limb or if the limb is used rotation of the body or flexion of the hip with a large forward step to minimize knee flexion. This fear/avoidance behavior further affects the firing pattern of the muscles around the joint. A recent study by Bennell et al[51] where a painful electric shock was applied randomly across the patella in asymptomatic individuals while they were ascending and descending stairs demonstrated a significant decrease in VMO activity relative to the preexperimental condition, whereas the VL activity did not change.

MANAGEMENT OF ACUTE PATELLOFEMORAL INSTABILITY

As the medial patellofemoral structures have been disrupted, it is imperative for the clinician to shorten these structures to optimize healing. Many practitioners would place the patient in a knee immobilizer with crutches to weight bear as much as pain allows. There are several patellofemoral braces claiming varying degrees of success in stabilizing the patellofemoral joint, which could be used for the acute dislocation.[52–54] However, firm taping to shorten the medial retinacular tissue and MPFL, providing stability for the disrupted tissue, often allows a more normal gait pattern and may improve the outcome of rehabilitation, but this is yet to be subjected to a randomized controlled clinical trial. Initially the patella is taped medially, then the medial retinacular structures are shortened with the tape forming a V shape on the medial joint line (Fig. 1). The tape starts on the tibia being pulled toward the medial femoral epicondyle while the soft tissue is lifted toward the patella. The second piece starts at the medial epicondyle and is angled up onto the VM while the soft tissue is again lifted toward the patella. This process may be repeated 2 or 3 times until there is sufficient medial stability and the patient can weight bear better. Depending on the severity of the dislocation, some patients may require shortening of the soft tissue on the lateral side so there is a diamond appearance of tape around the patella. Some patients may still need crutches for ambulation for a short period of time.

FIGURE 1. Taping to shorten an elongated medial retinaculum and MPFL.

Initially, the aim of treatment is to decrease the swelling, promote VMO and gluteal activity and gain controlled knee flexion range. Swelling has a detrimental effect on quadriceps muscle activity,[55] so the faster the swelling is reduced the better the outcome for the patient. Soft tissue massage is effective in decreasing swelling which in turn will help knee flexion. Ice is effective for the first 48 hours postinjury and in the first 3 to 4 weeks postinjury for the patient who has been weight-bearing too long. Electrotherapy modalities such as muscle stimulation, interferential, and ultrasound can be effective in reducing swelling. Muscle stimulation over the VMO may be used in combination with isometric contractions of quadriceps and gluteal muscles. Gentle controlled proprioceptive neuromuscular facilitation hold/relax techniques within the limits of pain, at first with the patient in high sitting, can be used after 2 to 3 weeks to gain some flexion range. The knee must be taped to protect the retinaculum while these exercises are performed. The patient may exercise for range of motion only on an exercise bike (only going as far as pain will allow) they may not be able to do a full revolution on the bike so they can peddle back and forward within their pain-free range. As the range improves and the swelling decreases, the hold/relax techniques can be performed in prone. Small range knee bends with weight equally distributed through both legs and isometric gluteal contraction may be performed with a muscle stimulator and/or a biofeedback. To protect against further instability of the patellofemoral joint, the knee is often flexed so the normal heel/toe pattern in gait is lost, so gait training must begin fairly early in rehabilitation to minimize stress on other areas of the body. Other rehabilitative techniques will be covered after the recurrent subluxation section as the principles apply to both groups of patients.

MANAGEMENT OF RECURRENT PATELLOFEMORAL INSTABILITY

Patients with recurrent instability have hypermobile patellae so the patella must be stabilized. This can be performed by using a brace or tape. Taping the patella can often determine if a brace will be effective in controlling the excessive patellar motion. A hypoallergenic tape is usually placed underneath the rigid sports tape to provide a protective layer for the skin. If skin problems persist, a plastic coating (applied as either a spray, roll-on or plastic film) or calamine lotion, which

FIGURE 2. Recurrent patellofemoral instability—tape to control seating of the patella in the trochlea.

has been allowed to dry, may be applied to the skin prior to taping. To stabilize the patella with tape, the patella is usually tilted first because when the patella is moved in a medial direction the medial border will move anteriorly indicating relatively tight deep lateral retinacular structures. A medial glide tape is then applied to the patella followed by an external rotation tape applied superiorly and inferiorly to improve the seating of the patella in the trochlea (Fig. 2). Taping the patella has been found to:

(i) increase quadriceps muscle torque[56,57]
(ii) increase loading knee flexion response[58]
(iii) activate VMO earlier than VL during stair ascent and descent.[43,59]

STRETCHING TIGHT SOFT TISSUE STRUCTURES

The deep lateral retinacular structures may require stretching, which can be done in side lying. The anterior hip structures are usually tight as these individuals often have anteverted femurs. These structures may be stretched in a "figure-of-four" position in prone. The malleolus of the bent leg is placed under the straight leg at the level of the tibial tuberosity. The patient elongates the thigh toward the wall. The stretch is usually held for 5 seconds and repeated for 5 times. If there is a pull anteriorly, the patient can hold the anterior soft tissues, lifting the adductors firmly toward the head to take the tension off these structures.

OTHER TAPING TO ENHANCE MUSCLE ACTIVATION

Frequently, the gluteal muscles are not firing well, so the patient exhibits adduction and internal rotation of the femur during weight-bearing activities, so taping the gluteal muscles can improve the stability of the pelvis. This tape is applied once a week for a couple of weeks, because improved gluteal activation occurs relatively quickly. Kilbreath et al[60] recently demonstrated improved hip extension in a group of stroke patients after gluteal taping. The subjects, who had experienced a stroke between 2 and 11 years ago, walked at 2 different speeds (self-selected and fast) under 3 different conditions (control, therapeutic, and placebo tape). With the therapeutic tape in situ subjects went from 3 degrees of hip flexion in the control situation to 11-degree extension in self-selected walking speed and 8 degrees in fast walking. No difference was found with placebo tape.

FIGURE 3. Tape to promote external rotation of the femur.

If the patient is unable to control the femoral position, tape may be used to externally rotate the femur giving a proprioceptive reminder to the patient, not to internally rotate (Fig. 3). Unfortunately, this tape is not as well tolerated because it causes a skin pull on the thigh and the sacrum during sitting. However, it usually only needs to be applied for a short period of time while the motor recruitment pattern changes.

If the patient is having difficulty recruiting the VMO or the VMO activity is less than the VL, the VL can be inhibited, by applying firm tapes from mid thigh across the lateral aspect of the thigh. A recent within-subject placebo-controlled trial on asymptomatic individuals, found that this inhibitory tape significantly reduced the EMG activity of VL compared with no tape or placebo tape in a stair descent task.[61]

MUSCLE TRAINING

Individuals with patellofemoral instability need to up-train the VMO and the gluteal musculature to improve the dynamic stability of the patellofemoral joint. How is this achieved?

Before progressing further into exercise prescription for the patellofemoral instability, some discussion is required on the importance of training specificity. A recent study by Jensen et al[62] comparing 4 weeks of strength training versus visuomotor skill training of the biceps brachii demonstrated statistically significant changes as measured by transcranial magnetic stimulation in corticospinal excitability in the skill training group but not in the strength training group. This study confirms what has been previously established in the literature about the importance of specific training to facilitate skill improvement.[63–65] It is possible to identify at least 4 aspects of strength training specificity:

(i) Strength training effects are largely muscle specific.[66]
(ii) The training effect is joint angle specific, that is, if a muscle is trained isometrically at one angle or dynamically through a limited range, then the increases in strength occur where the training has taken place with limited increases at other joint angles.[67]
(iii) The training response is specific to the type of contraction and the velocity of the contraction.[68]
(iv) Training is specific to limb position,[63] that is, there is a postural specificity to training, so we are training synergistic muscle activation patterns.

For the patellofemoral joint, there is increasing evidence that weight-bearing or closed chain training is more effective than open chain exercises. Stensdotter et al[69] found in asymptomatic subjects that closed chain knee extension, promoted a more simultaneous onset of EMG activity of the 4 different muscle portions of the quadriceps compared with open chain. In open chain, rectus femoris had the earliest EMG onset while the VMO was activated last with smaller amplitude than in closed chain. These authors concluded that closed kinetic chain exercise promotes a more balanced initial quadriceps activation than open kinetic chain exercise. This supports the previous finding of Escamilla et al,[70] who found that open kinetic chain exercises produced more rectus femoris activity with closed chain exercises producing more vasti activity. Closed kinetic training allows simultaneous training not only of the vasti but also the gluteals and trunk muscles to control the limb position in weight-bearing.

Controlling the patella is difficult as many of these individuals have passive instability issues so the neuromuscular control must be extremely efficient to minimize lateral shift in these individuals. The VMO will often have to be greater than 4 × the lateralis and come in strongly from the beginning of range. Hence, muscle stimulation is often used in conjunction with training in the beginning as patients attempt to gain control of their patella in sitting. Dual channel biofeedback with electrodes placed on the VMO and VL helps the patient to optimize the firing patterns of the VMO and VL, which significantly enhance the muscle training particularly in weight-bearing.

IMPROVING DISTAL CONTROL

Patients with patellofemoral instability usually have extremely poor inner range quadriceps control, so their knee generally locks and dramatically unlocks at 20 to 30 degrees with a subsequent patellar subluxation. Therefore, small range weight-bearing activities in front of a mirror are commenced early in the retraining program, so the patient can ensure an optimal alignment of the lower limb. This must be performed in the pain-free and relocated range, in the first 30 degrees of knee flexion, where the patellar position has been controlled by tape and the patient can control the femoral position by keeping the hip, knee, and foot aligned. The essential aspect of training in early stages of rehabilitation is that emphasis should be given to the timing and intensity of the VMO contraction relative to the VL. The patient starts with the feet positioned pelvis-width apart, facing forward, and with the weight distributed either equally on both feet, or partially through the symptomatic limb. The patient is instructed to maintain the pelvis, hips, knees, and feet in a forward-facing alignment by squeezing the gluteals, whereas the knees are slowly flexed to 30 degrees and then returned to full extension without locking the knees back.

VMO retraining can progress to small range flexion and extension movements in the walk stance position, with the VMO constantly active. This position not only simulates the motion of the knee during the stance phase of walking, but it is also the position where VMO recruitment is poor and the seating of the patella in the trochlea is critical. Again, emphasis should be given to the timing and intensity of the contraction of VMO relative to VL.

IMPROVING PROXIMAL CONTROL

Training the gluteal musculature to improve stance phase of gait is required to decrease the lack of femoral control in weight-bearing and improve the stability of the lower extremity. The patient stands with the asymptomatic leg closest to the wall at a distance of a fist away from the wall. The patient's whole body is turned 30 degrees into the wall and the weight is transferred to the outside (symptomatic) leg. The knee of the leg closest to the wall is flexed to 60 degrees with the knee touching, not pushing the wall, for balance purposes. The foot is off the ground. The hips are kept in neutral position so the thighs are parallel. The patient's weight is directed through the heel of the weight-bearing leg, the pelvis is slightly posteriorly tilted and the knee is slightly flexed. The patient externally rotates the standing leg without turning the foot, the pelvis, or the shoulders. The patient should sustain the contraction for 20 seconds, so a burning can be felt in the gluteus medius region (Fig. 4A). The patient can progress this by flexing the hip of the non–weight-bearing leg to 90 degrees. Again, the knee just touches the wall for balance while the patient externally rotates the standing leg without moving the foot, pelvis, or shoulders (Fig. 4B). These positions improve the patient's core

FIGURE 4. A, Training the gluteals, simulating stance phase of gait with hips in neutral. B, Training the gluteals, simulating stance phase of gait, with non–weight-bearing hip at 90 degrees.

control for the single support phase of walking and the strike phase of running. The training may be progressed to standing on 1 leg where the pelvis is kept level and the lower abdominals and the glutei are worked together while the other leg is swinging back and forward, simulating the stance phase of gait. This is better performed in front of the mirror so the patient receives feedback about body alignment and limb position.

As these exercises require a degree of coordination, some patients may need to be more stable initially, so they can stand parallel to a wall, keeping both feet on the floor and isometrically abduct both legs, with the weight back through the heels and the knees slightly flexed. This triggers a less specific gluteal contraction but it improves the patient's awareness of the gluteal musculature. Some patients also benefit from using an elasticized band/tubing around the ankles for resistance. The patient stands on the symptomatic leg while extending and abducting the asymptomatic leg to 45 degrees without rotating or tilting the pelvis (Fig. 5). The patient aims to do as many repetitions as he/she can without losing control of the pelvis. The number of repetitions and/or the thickness of the tubing can be increased as the patient improves.

If the patient has poor balance and is not be able to perform the weight-bearing exercises described above, a more stable position of side lying is preferable where the patient has the hips and knees flexed to 90 degrees and lifts the top knee away from the bottom knee while keeping the feet together (clam exercise). Once pelvic control has improved, step training can be implemented.

The patients need to practice stepping up and down, initially using a small step. This should be performed slowly, in front of a mirror, so that changes in limb alignment can be observed and deviations can be observed and corrected. Some patients may be able to do only a small number of repetitions with correct lower limb alignment. Since inappropriate practice can be detrimental to learning, a small number of exercises with correct alignment are sufficient. These exercises should be performed frequently throughout the day with the number of repetitions being increased as the skill level improves. For further progression, the patient can move to a larger step, initially decreasing the number of contractions and then slowly increasing the exercises again. As the patellofemoral stability improves, the patient can alter the speed of the stepping activity, the amount of range used, and rate of the change of direction. Weights may be introduced in the hands or in a backpack. Initially, the number of repetitions and the speed of the movement should be decreased, and slowly built back up again. The aim of retraining is to make the transition from functional exercises to functional activities. Training should be applicable to the patient's activities/sport, so that a jumping athlete, for example, should have jumping incorporated in the program. Figure-of-eight running, bounding, jumping off boxes, jumping, and turning, and other plyometric routines are particularly appropriate for the high performance athlete. However, the patient's VMO needs to be monitored at all times for timing and level of contraction relative to the VL (Fig. 6).

As the VMO plays an important stabilizing role for the patellofemoral joint, endurance training is the ultimate goal. The number of repetitions performed by the patient at a training session will depend on the onset

FIGURE 5. Training the gluteals using elasticized band, VL inhibitory tape in situ.

FIGURE 6. Functional training of the quadriceps, monitoring VMO, and VL activity.

of muscle fatigue. Initially, it is important to emphasize quality and not quantity, progressing to increase the number of repetitions before the onset of fatigue. Patients should be taught to recognize muscle fatigue or quivering, so that they do not train through the fatigue and risk exacerbating their symptoms.

DAILY STRATEGIES

Patellofemoral instability cannot be cured but can be managed by ensuring that the exercise regime is incorporated into the patient's daily routine. The exercises should only take 5 minutes otherwise the patient is unlikely to continue with the exercises. The patient needs to realize that to keep the knee in "good health," that is fewer instability episodes, these exercises are like cleaning their teeth—essential part of body maintenance. No more than 4, but preferably 3 exercises should be given and should consist of weight-bearing gluteal training, small squats, and anterior hip stretches, where no equipment is needed so the patient can do the exercises at any time and place. Patients need advice on how to stand, how to get out of a chair, how to turn and lift objects to decrease the rotational force through the patellofemoral joint in their everyday life.

The patient should stand with the heel of front foot positioned into the instep of the back foot, the legs will slightly externally rotate, the knees should be soft and some part of one leg should touch the other leg (like third position in ballet, Fig. 7). Minimal muscle activity is required to maintain this position, so there is improved control in the neutral zone and a decreased likelihood of patellofemoral instability. When getting out of chair, the patient's tibia should remain directly underneath the femur, as the patellofemoral joint is vulnerable if the tibia is displaced laterally relative to the femur. The vulnerability of the patellofemoral joint is particularly a concern in weight-bearing when the foot is fixed and the body turns on the fixed foot, causing the femur to internally rotate relative to the tibia. The patient needs to practice turning the whole body so the weight is transferred onto the nearest leg in the direction of the turn, lifting the heel of the back foot off the ground. Both feet should be facing in the direction of the turn. All these maneuvers need to be practised regularly so they become automatic and the patellofemoral joint becomes more robust and less susceptible to instability episodes.

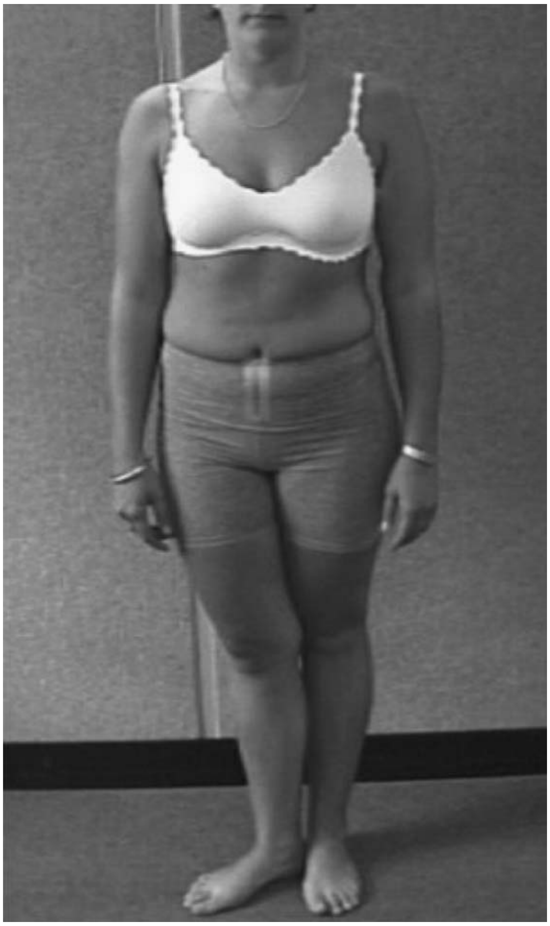

FIGURE 7. Recommended standing position—like third position in ballet. Legs self-supporting; knees not hyperextended.

EVIDENCE

It has been found that 6 weeks of 1 session per week of physical therapy treatment changes the onset timing of VMO relative to VL during stair stepping and postural perturbation tasks. At baseline in both the placebo and treatment groups, the VMO came on significantly later than the VL. After the treatment, there was no change in muscle onset timing of the placebo group, but in the physiotherapy group, the onset of VMO and VL occurred simultaneously during concentric activity and VMO preceded VL during eccentric activity.[71]

A recent 6 treatment randomized, double-blind, placebo-controlled trial which included specific weight-bearing gluteal and VMO training, and also anterior hip structure stretches showed that the physical therapy group demonstrated a significantly better response to treatment and greater improvements in pain and functional activities than the placebo group.[72] Hence, physical therapy is effective in improving pain and function in PFP patients and also altering VMO onset relative to VL.

CONCLUSIONS

Management of patellofemoral instability requires an understanding of the factors contributing to the instability. Acute dislocation initially requires a minimization of stretch to the elongated medial structures to optimize healing. This can be accomplished by taping or bracing. Muscle training with emphasis on alignment of the lower extremity is the priority for both acute and recurrent instability patients. This will involve the gluteal musculature to control femoral position and lower limb alignment and the VMO to improve the seating of the patella in the trochlea. In some instances, however, the lack of bony restraint that some of these patients present with, makes it difficult for even the best trained muscles to control the forces placed on the patellofemoral joint particularly during sporting activities, so surgical assistance to improve the passive stability of the joint may be required.

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