Assessment and management of chronic patellofemoral instability

Chronic patellofemoral instability can be a disabling condition. Management of patients with this condition has improved owing to our increased knowledge of the functional anatomy of the patellofemoral joint. Accurate assessment of the underlying pathology in the unstable joint enables the formulation of appropriate treatment. The surgical technique employed in patients for whom non-operative management has failed should address the diagnosed abnormality. We have reviewed the literature on the stabilising features of the patellofemoral joint, the recommended investigations and the appropriate forms of treatment.

There have been a number of clinical1-8 and MRI studies9-15 describing the various components of the knee extensor mechanism which are important in patellar stability. The stability of a joint depends on the underlying morphology and the balance of static and dynamic soft-tissue forces that interact in a complex way.

Anatomical and physiological considerations

**Morphology of the trochlea and patella.** The normal shape of the trochlea is a concave trough16 formed by the contour of the bone and overlying articular cartilage. The patella has a convex articular surface with seven facets for contact with the femur. The congruity between the patella and the trochlea provides some constraint to the patellofemoral joint.7 The role of patellofemoral dysplasia has only recently been fully appreciated and implicated in patellar dislocation.17-19 The dysplastic trochlea may be a flat surface or dome shaped (Fig. 1), with the distal pole of the patella flattened where it articulates with the dysplastic trochlea in the extended knee. However, the proximal pole usually retains its normal convexity, as it engages during flexion into the more normal distal trochlea. In the normal knee the patella and trochlea engage early in knee flexion. The cartilaginous contour in the trochlea may vary from that of the underlying bone,20,21 accentuating dysplasia. MR imaging therefore has an important role in the assessment of trochlear morphology.

**Bony alignment and rotational profile.** Lower limb alignment and the attachment points of the extensor mechanism influence the complex vectors of the knee.22 The Q angle is the vector between the patellar ligament and the quadriceps tendon. An increasing Q angle increases the pressures on the lateral patellar facet.23 The resulting effect on lateral displacement of the patella depends on the angle of knee flexion and the competence of the trochlea and soft-tissue restraints.24,25 Estimation of the Q angle can be performed clinically, but can be difficult owing to body habitus, bony rotational deformities and change in the position of the patella with knee flexion.26,27 An alternative measurement is the tibial tubercle to trochlear groove offset on superimposed axial images through the trochlea and tubercle from CT or MR scans (Fig. 2).

Rotational deformities that increase the risk of patellofemoral instability include increased femoral neck anteversion, torsional deformities of the femoral shaft, external tibial torsion and excessive varus at the subtalar joint.

With a shallow trochlear groove, soft-tissue factors play a major role in stabilising the patella.28,29 It has been noted that generalised ligamentous laxity increases the risk of patellar instability.30 Stability is also determined by specific static and dynamic constraints.

**Static soft-tissue constraints.** Static soft-tissue constraints are most important when the patella is not engaged in the trochlea.

**Medial patellofemoral ligament.** This ligament runs from the medial femoral condyle deep to the vastus medialis obliquus to the proximal two-thirds of the patella.25 It is the most important medial static structure limiting...
lateral patellar displacement, and contributes up to 60% of stability. The medial patellofemoral ligament is particularly important in patients with increased tibial tubercle to trochlear grade offset, vastus medialis obliquus dysplasia and trochlear dysplasia. It may be difficult to identify and has been shown to be variable in size. Patients are at a higher risk of recurrent dislocation after an initial dislocation if the medial patellofemoral ligament is poorly developed. The ligament can be assessed on MR scans.

*Ligamentum patellae.* Patella alta results in lack of containment of the patella in the trochlea (Fig. 3). With associated malalignment, the patellar ligament may impinge on the lateral femoral condyle, known as lateral patella tendon conflict (Fig. 4).

*Lateral sided fascial system.* The lateral sided fascial system has a superficial oblique layer and a deep transverse layer. The deep transverse fibres insert predominantly into the posterior aspect of the fascia lata and act as the lateral patellofemoral ligament.

*Other ligaments.* Other stabilisers of the patellofemoral joint include the patellomeniscal and patellotibial ligaments which occur on the medial and lateral sides, respectively. The patellomeniscal ligament plays a dominant role, with 13% to 22% of the medial restraining force being attributed to it. At present little consideration has been given
to these other ligaments with respect to radiological assessment and management.

**Dynamic soft-tissue constraints.** The rectus femoris, vastus lateralis, vastus intermedius and vastus medialis insert in a layered arrangement on to the proximal patella, creating different vectors of force on the patella,33,60 but their influence on the stability at the patellofemoral joint remains controversial.24 The lower part of vastus medialis, known as vastus medialis obliquus, may be important in patellar instability.30-42 The vastus medialis obliquus and the medial patellofemoral ligament probably act together as a combined dynamic complex.12

The vastus lateralis is variable in length, volume, cross-sectional area and orientation.24 The little-understood obliquus component13 inserts into the extensor mechanism at an average angle of 38° to 48° to the sagittal plane, whereas vastus lateralis longus inserts at an angle of 12° to 15°.41 The role of the vastus lateralis obliquus in patellofemoral instability remains uncertain.

Despite the controversy and uncertainty relating to these dynamic stabilisers, there are many surgical soft-tissue procedures and physiotherapy programmes directed at the quadriceps.

**The clinical course**

Risk factors for recurrent instability can be determined in the clinical history.36,44,45 Female adolescents are the most common first-time dislocators. Following primary dislocation, 17% of patients experience subsequent instability. If the patient already has a history of subluxation or dislocation, 50% will have further episodes of instability. The younger a patient is at the time of the first dislocation and the more severe the dislocation, the greater the risk of subsequent dislocation.36,46 A family history of instability of the patella and the presence of risk factors for developmental dysplasia of the first hip (first-born girl, high birth-weight, breech delivery, and delivery by Caesarian section) are associated with recurrent instability.47,48

It is important to consider the patient in general and to examine the opposite knee, as abnormal findings are often symmetrical.

**Generalised ligamentous laxity.** Evidence for this should be sought using established scoring systems during the initial examination.

**Lower limb alignment.** The overall alignment of the lower limb should be assessed. The foot progression angle, thigh to foot angle (with the knee flexed at 90°) and hip rotation in the prone position with the knee flexed should all be noted. Increased valgus angulation at the knee and hyper-extension will predispose to patellar instability.

The height, size and mobility of the patella may be assessed, although these are very observer dependent, as is the Q angle. The Q angle can be estimated in the supine position with the knees extended or in 90° of flexion.49

**Specific examination of the knee with patellar instability.** The most reliable signs in the patient with patellofemoral instability are the apprehension test and perhaps anxiety during examination. Many other described signs are not routinely used. An abrupt lateral movement of the patella as the knee approaches full extension is known as the J sign. It is non-specific and in our experience is often absent in patients with severe dysplasia. The patella can be assessed for tilt and glide in the medial and lateral directions.50 Patellar tilt may be produced by residual laxity in the medial structures19,51 or by a tight lateral retinaculum.49,50 Patellar glide can be assessed at 30° of knee flexion and should be fewer than two quadrants in a medial or lateral direction.49,52 Other causes of anterior knee pain and instability of the knee should be excluded.

**Imaging of the knee with chronic instability.** Many imaging modalities and measurements have been described to investigate the patellofemoral joint.53,54 The methods and measurements used in our institution are selected for reliability, simplicity, and their usefulness in decision making.

**Plain radiographs.** An anteroposterior radiograph of the knee will exclude osteochondral pathology and osteoarthritis of the tibiofemoral joint. Relocation injury of the lateral femoral condyle and loose bodies may be seen. All these disorders can mimic patellofemoral symptoms.

The lateral radiograph provides more information. Patella alta can be assessed using the Insall-Salvati55 or Blackburne and Peel56 methods. Trochlear dysplasia can be classified based on the lateral radiological view57 (Fig. 5). A shallow trochlea58 and a crossing sign57 are features of dysplasia. For a reliable crossing sign a true lateral of the distal femur is required.59,60

The skyline patellar view should be performed at 30° to 45° of knee flexion (Laurin or Merchant views).61,62 Stress, dynamic (radiographs with contracted quadriceps) and weight-bearing skyline views have also been described,53,58,63 although these are not used in our institution. Numerous measurements, including the sulcus angle,
congruence angle, lateral patellofemoral angle, lateral trochlear inclination and patellofemoral index have been described. The usefulness of all these measurements is questionable. Severe trochlear dysplasia, subluxation and tilt of the patella, and patellofemoral degenerative disease can all be demonstrated in skyline views of the patella.

As it may be difficult to obtain reproducible and perfectly aligned radiographs, MR scans are recommended as an adjunct if surgical treatment is being considered. CT scans have been widely used in the assessment of chronic instability. Images can be created at different degrees of flexion and with or without quadriceps contraction, although there are no published data on the usefulness or interpretation of the images. CT has a role in the assessment of complex rotational alignment deformity, and as mentioned previously, may also be used to determine the tibial tubercle to trochlea groove offset.

MR imaging. MR scans provide invaluable information on the multifactorial aspects of patellofemoral instability and are the authors’ primary investigation of choice. Axial images. The axial T2 fat saturation images reliably demonstrate trochlear and patellar dysplasia. The articular cartilage contour usually differs from that of the underlying bone and accentuates any dysplasia. Large chondral defects can be demonstrated in the patellofemoral region, although in our experience the scans can be misleading in assessing the quality of the articular cartilage. Tilting of the patella and the integrity of medial patellofemoral structures (predominantly the medial patellofemoral ligament) can be assessed, and avulsion fragments on the medial side of the patella can be visualised. Patellar tendon conflict may be apparent, usually in the presence of patella alta. The signal returned by the ligamentum patellae may be altered and that from the fat pad may be absent (Fig. 4).

The tibial tubercle to trochlear groove offset can be measured by overlapping axial scans of the tibial tubercle and trochlear groove, with an offset of more than 15 mm to 18 mm being considered abnormal. It is likely that the classical pattern of bone bruising due to recent dislocation will be seen on these images. Sagittal images. Patellar height can be measured using a variety of ratios, as in the plain radiographs. However, these ratios may be very misleading, because in trochlear dysplasia the trochlear surface is generally foreshortened as well as domed, and the patella sits well above the surface of the trochlea in extension, despite being of normal height. This will be appreciated better on the axial images. The dysplastic patella is also small, giving a false impression of patella alta.

Formulating a surgical management plan

Many surgical procedures have been described for the treatment of patellofemoral instability. Surgery should not be considered until non-operative treatment has failed and the recurrent nature of the disease has resulted in functional impairment. Non-operative treatment should consist of anti-inflammatory and analgesic medication in combination with physiotherapy and trial of taping. Physiotherapy is directed towards closed chain exercises and vastus medialis obliquus strengthening. Surgery may address either bone or soft-tissue components. Options include proximal, intra-articular or distal procedures (Table I). Each symptomatic knee must be carefully considered and treatment individualised according to the anatomical abnormality. Skeletally immature patients are particularly demanding, as bony procedures should be avoided until maturity. In the authors’ opinion the surgical strategy should, wherever possible, aim to restore normal anatomy rather than introduce new abnormalities.

A common form of malalignment is a large Q angle or tibial tubercle to trochlear groove offset. A symptomatic patient with an isolated tibial tubercle to trochlear groove offset of > 15 mm will benefit from a medialising osteotomy to return the tibial tubercle to a normal position. The tubercle is generally internally rotated in addition to medialisation in order to address the tilt of the ligamentum patellae. To assess the correction achieved we favour an arthroscopic examination of the patellofemoral joint via the superolateral portal. This portal is positioned just lateral to the rectus femoris tendon and as high as possible in the suprapatellar pouch (Fig. 6). This enables assessment of the patellofemoral joint through a range of movement. If lateral patellar tilt as well as subluxation is demonstrated, an extrasynovial lateral release is combined with a tibial tubercle transfer to allow correction. The author’s opinion is that an isolated lateral release in the presence of subluxation is contraindicated. The patellofemoral joint is then reassessed through the superolateral portal. If subluxation...
persists in full extension a proximal soft-tissue procedure (reconstruction of the medial patellofemoral ligament or a medial reefing procedure) may be performed. Patella alta with instability or patellar tendon conflict can be treated with distalisation of the tibial tubercle.\textsuperscript{71,72}

Trochlear dysplasia is treated with a trochleoplasty, provided there is no degenerative change within the joint. The creation of a deepened groove also alters the tibial tunnel to trochlear groove distance as the depth of the trochlea is lateralised and may reduce the need for medialisation of the tibial tubercle. Occasionally, trochleoplasty alone will not provide sufficient stability and additional surgical procedures will be required (Fig. 7). Supplementary procedures will be guided by pre-operative anatomical assessment. The early and mid-term results of trochleoplasty are encouraging.\textsuperscript{73,78} Instability following trochleoplasty is uncommon. Patient satisfaction rates are high. The longest published results for trochleoplasty are after a mean of 8.3 years (4 to 14).\textsuperscript{73} All patients in this series reported they would undergo the surgery again, despite evidence of greater than grade II radiological patellofemoral changes in 30\%. Histological examination has shown a normal matrix and cell distribution of the cartilage post-trochleoplasty\textsuperscript{74} thus alleviating concerns regarding the subsequent viability of the cartilage at six to nine months post-surgery. It is important that outcomes for these patients continue to be reviewed on an ongoing basis.
If the tibial tubercle to trochlear groove offset and alignment are normal, consideration can be given to proximal soft-tissue procedures, including medial soft-tissue procedures (vastus medialis obliquus advancement and reconstruction of the medial patellofemoral ligament) and lateral release. Reconstruction of the medial patellofemoral ligament has been described recently with good short-term results. Reconstruction of the medial patellofemoral ligament has reduced recurrent instability of the patellofemoral joint with success in 83% to 90% of patients. Patient satisfaction rates are high despite many having postoperative crepitus. The longest published results are four to five years post-repair. Outcomes with medial patellofemoral ligament reconstruction alone in patients with trochlear dysplasia may not be as good. The authors favor the use of a semitendinosus autograft. It is important but challenging to identify isometric insertion points and achieve appropriate graft tension. Over-tightening and poor graft positioning can result in increased joint forces on the medial patellofemoral joint. Other anatomical abnormalities can stretch the reconstruction. Vastus medialis obliquus advancement will stabilise the patella, but is usually performed in combination with other realignment procedures when the medial retinaculum is lax. A lateral release may be helpful in the presence of lateral tilting of the patella due to tight lateral structures, and may be performed in an open or arthroscopic manner. Although good results have been reported with isolated lateral release, this is not uniformly the case. The authors generally only use lateral release in combination with other stabilising procedures, and favour an extended extrasynovial lateral release including the vastus lateralis obliquus tendon.

These soft-tissue procedures can be used in conjunction with bony procedures, depending on the anatomical abnormalities present (Fig. 8).

In the presence of degenerative joint disease, surgical treatment becomes difficult and has a guarded prognosis. Anatomical abnormalities resulting in instability need to be addressed, and steps to repair or restore the articular cartilage can be considered. If the articular lesion is localised to one side of the joint then stimulation of cartilage healing with micro-fracture or cartilage restoration with Matrix-induced autologous chondrocyte implantation or osteochondral allograft transfer system can be used. If degeneration is present on both joint surfaces, salvage surgery will be required. Options include chondroplasty, lateral release and tibial tubercle elevation. With previous unsuccessful surgery or advanced degenerative disease, compartmental or total knee arthroplasty is the only surgical option.

The natural history of the unstable patellofemoral joint, with or without surgery, is not well established. Some report that degenerative change is uncommon and requires over five years to develop. Patients with a primary dislocation of the patella treated non-operatively showed degenerative disease in 11% to 22% of cases at six to 26 years after injury. In 35% of patients requiring late surgery for recurrent instability, degenerative change was present. Other studies have also shown an increased incidence of osteoarthritis in the operated group, possibly as a result of over-correction or a failure to recognise and treat the underlying abnormality. There is no evidence that surgical stabilisation of the patellofemoral joint decreases long-term degenerative change despite improving short-term stability.

Conclusion

The accurate assessment and management of the unstable patellofemoral joint depends on knowledge of the anatomy of the joint and its stabilising structures. The surgical strategy should, wherever possible, aim to restore normal anatomy to the joint, and will often involve a combination of surgical techniques.

References


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A modified test for patellar instability: can the TT-TG distance be measured clinically?


A. Runow

Fithian DC, Mishra DK, Balen PF, Stone ML, Daniel DM.

26. Shakespeare D, Fick D.

Patellar instability: the biomechanical basis.


29. Fithian DC, Mishra DK, Balen PF, Stone ML, Daniel DM.

27. Grelsamer RP, Dubey A, Weinstein CH.

28. Teigle RA, Feerber WW, Des Madryl P, Matete TM.


26. Shakespeare D, Fick D.


28. Teigle RA, Feerber WW, Des Madryl P, Matete TM.


29. Fithian DC, Mishra DK, Balen PF, Stone ML, Daniel DM.

27. Grelsamer RP, Dubey A, Weinstein CH.

28. Teigle RA, Feerber WW, Des Madryl P, Matete TM.


29. Fithian DC, Mishra DK, Balen PF, Stone ML, Daniel DM.

27. Grelsamer RP, Dubey A, Weinstein CH.

28. Teigle RA, Feerber WW, Des Madryl P, Matete TM.


29. Fithian DC, Mishra DK, Balen PF, Stone ML, Daniel DM.

27. Grelsamer RP, Dubey A, Weinstein CH.

28. Teigle RA, Feerber WW, Des Madryl P, Matete TM.


29. Fithian DC, Mishra DK, Balen PF, Stone ML, Daniel DM.

27. Grelsamer RP, Dubey A, Weinstein CH.

28. Teigle RA, Feerber WW, Des Madryl P, Matete TM.


