Staying in the groove
managing patellofemoral instability

INTRODUCTION

Patellar instability is a problem that regularly presents to orthopaedic surgeons. Surgical management for patellofemoral instability is uncommon, and most patients can be managed nonoperatively with good physiotherapy.

The treatment of patellofemoral joint (PFJ) instability can be challenging. Historically, most of the evidence behind management was based on level IV and V studies. The pathophysiology is varied, and the patients can cover a wide age range. As such, there is great reliance on clinical assessment and controversy about the most appropriate treatments.

The goal of the clinical assessment is to diagnose the pathophysiology driving the patellofemoral instability and to allow patient stratification, based on the abnormalities found, to guide treatment. Assessment needs to identify those patients presenting with functional instability (i.e. a knee that is giving way due to poor muscle control) versus those who have mechanical instability (abnormal anatomy). Confusingly, both features frequently coexist in the same patient.

ANATOMICAL CONSIDERATIONS

The stability of the PFJ is dependent upon bony and soft-tissue restraints. The anatomy and function of the PFJ means that the relative contribution from bony and soft-tissue restraints varies throughout the arc of knee movement.

In extension, and up to 30° flexion, the relative incongruency of the patella and trochlea means that the stability of the PFJ is greatly dependent upon static soft-tissue restraints. On the medial side, this stability is conferred statically by the medial patellofemoral ligament (MPFL), the medial retinaculum, and the medial patellotibial ligament, and dynamically by the vastus medialis obliquus. On the lateral side, the lateral retinaculum and the condensation into the deep transverse ligament confer the reciprocal stability.

The MPFL is the most important soft-tissue restraint on the medial side. Its origin is the groove between the adductor tubercle and the medial epicondyle. It inserts into the superomedial border on the upper two-thirds of the patella. The ligament contributes over 50% of the medial restraint to lateral displacement of the patella when the knee is in full extension during quadriceps contraction.[1] The MPFL is most taut at around 30° of knee flexion (at patellar engagement in the trochlear groove (TG)) in an anatomically normal knee. From this point onwards, into greater degrees of flexion, the majority of patellar stability is contributed by the bony shape of the TG and matching patella facets.

CLINICAL EXAMINATION

Following an acute patellar dislocation, if a patient is experiencing too much pain and swelling, a repeat clinical evaluation should be planned within a few weeks.

General examination of the PFJ

A Beighton score[2] should be carried out at the beginning of the examination to confirm or exclude the presence of hypermobility, and particularly noting the presence of knee hyperextension. Overall rotational alignment of the lower limb, including femoral anteversion, tibial torsion, and hyperpronation, should be noted.[3]

Knee examination

The presence or absence of an effusion should be noted. A large effusion may indicate an osteochondral injury immediately after a patellar dislocation or degenerative change following multiple episodes of patellar dislocation. The joint line including the extensor mechanism and the course of the medial patellofemoral ligament (MPFL) should be palpated for tenderness.

The range of movement of the knee should be recorded. The integrity of the cruciate and collateral ligaments must also be recorded, as one of the mimics of patellar dislocation is anterior cruciate ligament (ACL) rupture.

Patellar examination

The trochlear and anterior femur at the knee should be palpated to assess the presence and depth of a TG and the presence or absence of a supratrochlear spur should be noted. Patellar apprehension in extension and 30° flexion and the presence and strength of vastus medialis obliquus muscle should be assessed. A positive apprehension sign is when it reproduces the patient's pain or causes fear that the patella will dislocate. Apprehension can be from either

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verbal expression of anxiety or involuntary quadriceps muscle contraction. Mediolateral glide should be assessed both in full extension and at 30° of flexion.[4]

Patellar tracking should be assessed throughout the full range of knee movement, with the patient sitting on the edge of the bed. There are different types of patellar tracking movements,[5] but one of the most common is an exaggerated lateral to medial translation of the patella into the TG in early flexion.

RADIOLOGICAL ASSESSMENT OF THE PFJ

Plain radiographs are useful in the initial assessment of a patient with patellofemoral instability. The single most useful image is a perfect plain lateral in which the posterior condyles of the femur exactly overlap.[6] In this image, the patellar height and TG shape can be defined.

On the anteroposterior view, patellar position can be assessed. The anteroposterior plain film can confirm a normal tibiofemoral joint, may suggest patella alta, or may show a laterally placed patella or permanent patellar dislocation.

The skyline view of the PFJ can give information about the patellar shape, as well as avulsion fragments from the medial aspect of the patella and the presence of a medial patellar ossicle (MPO). A MPO has been previously described as being pathognomic for a patellar dislocation and is thought to arise following the rupture of the medial patellotibial ligament.[7]

The information that can be gleaned from the trochlear shape from the skyline radiograph is limited, as the position of the patella and trochlea depend upon on the degree of flexion at which the radiograph is taken.

ASSESSMENT OF PATELLAR HEIGHT ON A PERFECT PLAIN LATERAL FILM

Patella alta is a well-documented risk factor for patellar instability.[8] The following methods for patellar height measurement are in standard clinical practice and have been validated to discriminate between those patients with patellar instability and unaffected individuals.[9-11] These measurements are performed on a perfect lateral radiograph (i.e. one where the posterior femoral condyles perfectly overlap) (Figure 1).

Fig. 1. Perfect lateral radiograph of the knee demonstrating the overlap of the posterior femoral condyles. This can be used to assess for abnormalities of the patellofemoral joint.

The Insall-Salvati ratio[9] is defined as the ratio between the length of the patellar tendon and the length of the patella. Normal values lie between 0.8 and 1.2.

The Caton-Deschamps ratio[10] is the ratio between the distance from the lower edge of the articular surface of the patella and the anterosuperior corner of the tibial plateau to the length of the patella. Normal values lie between 0.6 and 1.2.

The Blackburne-Peel ratio[11] is the ratio of the articular length of the patella to the perpendicular distance from lower articular margin of patella to tibial plateau. The Blackburne-Peel ratio needs to be measured with the knee at 30° of flexion. Normal values lie between 0.54 and 1.06.

The Insall-Salvati and Caton-Deschamps ratios demonstrate a statistically significant difference in their ability to distinguish between healthy controls and those patients with patellar instability ($p < 0.0001$).[12]

KEY RADIOLOGICAL FINDINGS IN TROCHLEAR DYSPLASIA

The anatomy of the femoral trochlea is a significant determinant of patellofemoral instability. While uncommon, trochlear dysplasia is a powerful driver for recurrent patellar dislocation. The shape of the trochlear in trochlear dysplasia was classified by Dejour[13,14] into A (shallow trochlea, > 145°), B (flat trochlea), C (lateral convexity and medial hypoplasia), and D (cliff). The main feature of the classification is determined by the shape of the TG with respect to the anterior femoral cortex.

Trochlear dysplasia is classified into four grades based on shape of the trochlea.[8,13] The main elements within trochlear dysplasia are: 1) trochlear boss at the entry into the TG; 2) the shape of the lateral trochlear facet; and 3) the shape of the medial trochlear facet.[13,14]

In trochlear dysplasia, the pathognomonic sign is a crossing sign of the TG above the anterior border of the femoral condyles in conjunction with a medialized TG and a hypoplastic medial femoral condyle. On the plain radiographs, the medial condylar line joins the lateral condylar line distal to the point where the latter's chondral surface meets the anterior femoral cortex (Figures 2 and 3).

ADDITIONAL IMAGING

Plain radiographs have their limitations, as they only document the bony contours of the PFJ and the position of the patella in reference to the trochlea.

MRI scanning is useful to assess the articular cartilage and the relationship between the patellar articular surface and the trochlear articular cartilage in a method proposed by Biedert and Albrecht.[15] This measurement determines the patellotrochlear index (PTI) on sagittal MR images. The PTI is described as the percentage overlap of the patellar articular cartilage and the TG. The rationale behind this is that there is significant cartilage-bone mismatch in the sagittal plane of the PFJ. The osseous anatomy in the sagittal plane of the PFJ does not correspond with the articular cartilage surface.[15] They concluded that "index values of more than 50%

Fig. 2a

Fig. 2b

Fig. 2. a) Lateral radiograph of trochlear dysplasia. The groove line passes above the height of the anterior femoral cortical line. The screw in the patella is from a previous fixation of an avulsion fracture before referral. b) A proximo-superlateral MRI scan of the distal femur of the same patient.

document patella infera and less than 12.5% document patella alta" (Figure 4).[15]

CT scanning is used to measure the rotational profile of the lower limb and is useful in those cases where abnormalities in the rotational profile are found clinically, especially excessive femoral neck anteversion and excessive tibial external rotation. In addition, the measure of the relationship between the tibial tubercle (TT) and the TG can be determined. A lateralized TT promotes a lateral force on the patella, thereby increasing the risk of dislocation. The TT-TG relationship is measured on superimposed CT axial images taken at the level of the distal trochlea and the proximal portion of the TT[8] and is the distance between the lowest part of the TG and the highest part of the TT.[16] While an increased TT-TG is known to be associated with patellar instability, the absolute

Fig. 3. A mid-sagittal section of an MRI scan at the level of the anterior cruciate ligament demonstrating the trochlear boss of trochlear dysplasia.

Fig. 4. An MRI scan demonstrating a lack of overlap of the patella and trochlear articular cartilage.

value is questionable in determining the need for surgery and the type of surgery to be undertaken. There are also limitations in that the measurement is affected by trochlear dysplasia as, by definition, the TG is abnormal, and may be absent.

MANAGEMENT OF PATELLOFEMORAL INSTABILITY

Despite a wide range of both conservative and surgical modes of treatments being proposed, the management of patients who have had a first-time PFJ dislocation remains controversial. The findings of both a Cochrane review and separate meta-analysis concluded that there was insufficient evidence to establish whether surgical management of patients after a first time PFJ dislocation offers any benefit over non-operative management.[17,18]

Nonoperative

Physiotherapy is the mainstay of treatment for patients with hypermobility or muscular dyskinesia. The focus is on promoting vastus medialis obliquus and gluteal muscle activity and strength, as well as restoring full range of motion to the knee.

Immediately after a patellar dislocation, patients were historically placed in a plaster cast cylinder for up to six weeks before commencing physiotherapy. Such treatment is not recommended, as it promotes muscle wasting and prolongs subsequent rehabilitation.

The management strategy for an acute patellar dislocation should be a short period of rest until the acute swelling in the knee has settled before starting rehabilitation as soon as possible.

Operative

More than 100 operations in the treatment of patellar instability have been described. There is no consensus on the best single procedure.[6] Surgical interventions must be tailored to each individual patient and the challenge lies in accurately identifying the pathology driving the instability.

Widely utilized and effective operative options include MPFL reconstruction alone (deficient medial tissue), TT transfer (patellar distalization), and trocheoplasty. Reconstruction may consist of a combination of procedures.

Medial patellofemoral ligament repair

During a lateral patellar dislocation, the most commonly injured structure is the MPFL. The MPFL can be disrupted at any point along its length, from either femoral or patellar insertion, or midsubstance. Unfortunately, repair of the MPFL has not been found to be effective after patellar dislocation when compared with conservative treatment in either children or adults and therefore is not routinely recommended.[19]

MPFL reconstruction

The workhorse surgical technique for patellar instability is the surgery to reconstruct the

Fig. 5a

Fig. 5b

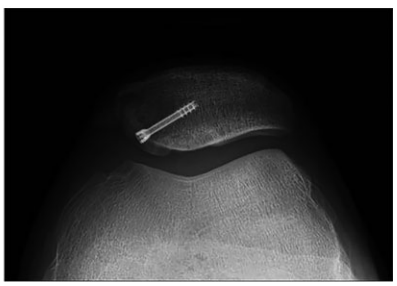

Fig. 5c

Fig. 5. a) Anteroposterior, b) lateral, and c) skyline radiographs demonstrating trochlear dysplasia. The screw in the patella is from a previous fixation of an avulsion fracture before referral.

medial patellofemoral ligament. MPFL reconstruction is aimed at guiding the patella into the trochlear groove during the first 30° of knee flexion. As an isolated procedure, it is the surgical treatment of choice for patients with normal anatomy and laxity of the medial patellar structures, functioning as a checkrein to lateral displacement of the patella. For patients with moderate to severe trochlear dysplasia or significant patella alta, it would not be recommended as an isolated treatment, but as part of a combination of procedures to address the concomitant pathology.[20]

Patients suitable for isolated MPFL reconstruction should have the following clinical examination findings: normal rotational profile and lower limb alignment; increased patellar mediolateral glide on full extension; patellar stability at 30° of flexion; and normal or slightly J-shaped patella tracking.

Imaging should support the clinical findings with radiological evidence of the rupture or stretching of the medial parapatellar tissues and must rule out significant trochlear dysplasia (with a boss height of < 4 mm to 6 mm) and patella alta of < 1.4 (Caton-Deschamps index).[21] Caution should be undertaken in operating on those patients with hypermobility, as poorer outcomes have been reported.[22]

The anatomical position for 'correct graft placement' has been of interest in recent years.[23] However, despite the publication of an isometric point for the femoral insertion of the MPFL, caution should be exercised about the blind faith in such a point, as the research was performed on cadavers with anatomically normal knees. Surgeons should therefore be familiar with the anatomical variations that affect the graft tension during the range of knee movement and the need to account for this during the reconstruction.[24] In addition, surgeons should avoid over-tensioning the graft and should be familiar with the length-tension behaviours of the graft during the full range of knee movement.

A variety of graft materials can be used including the adductor magnus tendon,[22-25] quadriceps tendon,[26] semitendinosus tendon,[25,27,28] and artificial ligaments with good results.[29] Overall, there are favourable clinical and radiological outcomes associated with MPFL reconstruction; however, further work is needed on graft and patient selection in order to further improve the results.[29]

TT transfer

There has been interest in the relationship of the TT to the TG and the effect of this distance on the stability of the PFJ. If the tubercle was seen to be pathologically lateralized compared to the trochlear grove, then surgical medialization of the TT, thereby decreasing the TT-TG distance and improving patellar tracking, would seem logical.

While the logic regarding medialization of the TT via TT transfer appears sound, there are now concerns about the validity of the absolute TT-TG measurement in terms of determining the rationale of tubercle medialization. There is therefore increasing resistance to its use, certainly as an isolated procedure.

By comparison, a number of authors have investigated the importance of patella alta in recurrent patellar instability and the subsequent role of surgical correction using TT transfer.[8,10,30,31]

In those patients defined as having patella alta (Insall-Salvati ratio > 1.2 and PTI < 12.5%) in conjunction with excessive medial sided soft-tissue laxity, distalization of the tubercle to correct the patella alta – with possible TT medialization to correct an increased TT-TG – led to significant improvements in patellar instability.[32-34] The PTI defines the degree of patella alta and therefore the degree of TT distalization needed can be planned. TT distalization combined with MPFL reconstruction addresses the instability in such patients.

Trocheoplasty

Significant trochlear dysplasia is a rare condition occurring in approximately 15% of patients presenting to a specialist patellofemoral clinic.[35,36] It is defined and classified radiologically by the presence of decreased height of the medial femoral condyle (hypoplasia); a decreased trochlear depth; an increased sulcus angle; and a lateral trochlear facet that is shallow, sometimes elevated or dome-shaped.[37]

The principal indication for a groove deepening trochleoplasty is in patients with recurrent patellar instability despite conservative management who have a severe hyperplastic

Fig. 6a

Fig. 6b

Fig. 6c

Fig. 6. a) Anteroposterior, b) lateral, and c) skyline postoperative radiographs after trochleoplasty and medial patellofemoral ligament reconstruction. The screw in the patella is from a previous fixation of an avulsion fracture before referral.

trochlear dysplasia.[35] Radiologically, the patients have trochlear dysplasia (Dejour types B, C, and D) with a boss height of > 4 mm.

Trochleoplasty addresses the anatomical features of trochlear dysplasia. All of the described techniques involve the removal of the trochlear boss with a subsequent groove deepening procedure (Figures 5 and 6). Additional procedures such as MPFL reconstruction, TT transfer, and lateral release may be performed simultaneously as part of an 'a la carte' approach.[14,38,39] Again, caution should be exercised in those patients who have hypermobility, as the MPFL autograft will be expected to stretch overtime.

It is important to identify those patients with hypoplasia of the lateral femoral condyle, as such patients will not benefit from a groove-deepening operation, but consideration should be given to a surgical elevation of the lateral trochlear facet rather than a deepening trochleoplasty.[3]

The literature on the outcomes of trochleoplasty is limited to outcome studies from multiple authors. The majority of authors report good outcomes in terms of patient satisfaction in conjunction with an improvement in patellofemoral instability and radiological indices. There is an increasing body of literature showing that the outcomes of trochleoplasty are favourable and that there is no clinical evidence of increased degenerative arthritis.[35,40,41] However, longer-term prospective studies are required to evaluate the outcomes of the procedure fully, particularly with respect to long-term degenerative change.

SURGICAL DECISION MAKING

The decisions regarding the surgical approach to PFJ instability remain difficult. Unfortunately for the treating surgeon, the majority of patients present with spectrum of radiological 'abnormalities'. It is therefore up to the surgeon, in conjunction with the patient, to determine which of the underlying pathologies can or should be addressed.

The goal of any intervention is to restore or achieve the best functional outcome and to create a stable PFJ throughout the full range of motion without creating long-term harm.

In the first instance, patellar instability secondary to rotational or longitudinal alignment abnormalities should be excluded.

In patients presenting with recurrent episodes of instability or subluxation who have failed conservative treatment and a radiologically normal PFJ, MPFL reconstruction alone gives good results.

For those patients with significant patella alta, TT distalization along with MPFL reconstruction should be the primary procedure of choice. The indications for medialization of the TT for PFJ dislocation are open to debate, but its role purely in decreasing an increased TT-TG in conjunction with an unstable patella is now less favoured.

Finally, in those patients with significant trochlear dysplasia, trochleoplasty along with MPFL reconstruction should be considered as the primary procedure, but consideration must be given to transfer of those patients to a surgeon with expertise in this procedure.

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