The Patellofemoral Joint

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Abstract

The patellofemoral joint has traditionally been poorly understood and interventions for patellofemoral joint problems have generally been less successful than those employed for the tibiofemoral joint. Pathologies affecting the patellofemoral joint in the adult can be largely divided into three groups: instability, osteochondral defects and osteoarthritis. These three conditions share a number of aetiological factors and all represent disorders of the normal mechanics of the patellofemoral articulation. As such, understanding the normal and abnormal anatomy and kinematics of the joint are vital to clinicians treating patellofemoral disorders. Treating the symptoms of these conditions without addressing the underlying disorder of kinematics will be likely to fail. In this chapter, the normal and abnormal anatomy and physiology of the joint are discussed as are the clinical features and treatments for the three commonly encountered pathologies of the patellofemoral joint.

Keywords

Patellofemoral joint • Disorders • Diagnosis • Treatment

5.1 Introduction

The patellofemoral joint is an important generator of symptoms within the knee joint in patients of all ages. In adults, the major pathologies are instability, osteochondral injuries and osteoarthritis. Common to all are disruptions to the complex biomechanics of the articulation. Understanding of the anatomy and physiology of the patellofemoral joint has lagged behind that of the tibiofemoral joint, but over recent years a

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great deal of research has been focussed on understanding the patellofemoral joint. The aim of this chapter is to describe the geometry and kinematics of the joint, and to apply these to the major pathologies encountered in the patellofemoral joint. By understanding the disorders of normal mechanics of the joint the surgeon can better understand the strategies for treatment of these traditionally difficult to treat pathologies.

5.2 Biomechanics

5.2.1 Geometry

While the bicondylar knee joint dates back to Eryops, an ancestor of reptiles, birds and mammals some 320 million years ago [1] the patellofemoral joint is a relatively recent development, dating back only 65 million years [2]. The patella is the largest sesamoid bone in the body and centralises the four converging heads of the quadriceps muscle group, transmitting their force and acting as a fulcrum. By extending the moment arm, it increases the power of knee extension [3–6].

The location and configuration of the intercondylar groove of the distal femur is clinically significant in the mechanics and pathomechanics of the patellofemoral articulation [5–8]. The traditional description of the femoral sulcus is that it lies midway between the femoral condyles, and this has informed many designs of total knee replacement. In fact, the native anatomy of the femoral sulcus is more complex than this. There is debate whether the femoral sulcus lies lateral to the midplane between the two femoral condyles [9] or central but with a distal-lateral deviation as the rotation of the femur increases during the arc of flexion [10]. The discrepancy may lie in the difference which is seen between bony and cartilaginous anatomy [11] or the fact that choosing different frames of reference while describing the circular trochlear groove would result in variable descriptions of its geometry [12]. Rotational variation is a key determinant of function and of predisposition to disease and the development of patellofemoral osteoarthritis has been related to increased external tibial torsion [13–15]. This rotation can be measured reliably using computed tomography (CT) scans [16].

5.2.2 Kinematics

The development of disease in the patellofemoral joint is influenced by abnormal joint kinematics [17] and knowledge of in vivo knee kinematics in healthy and arthritic knees is invaluable to understand the aetiology of patellofemoral disease and for surgical planning.

Patella tracking describes the motion of the patella relative to the femur during flexion and extension of the knee. There is a correlation between the anatomy of the patella and its facets with the trochlear groove of the femur [18], giving congruency and allowing the patella to move over the femur in a circular path [19]. Patellar maltracking can be a major contributor to knee pain in young knees [20–22] as well as leading to patellofemoral degenerative change and being one of the dominant causes of dissatisfaction following knee arthroplasty [23–25].

When the diaphysis of the femur is used as reference, lateral displacement of the patella has been observed with increasing knee flexion angle [26–32]. However, imaging studies have shown the opposite when relating the patella with the femoral trochlear groove (Figs. 5.1 and 5.2) [33, 34]. With three-dimensional tracking studies, there are difficulties in defining the groove axis and plane of reference as the trochlear groove is curved and different definitions of this axis have been used [35]. A reproducible axis has recently been defined between the centres of spheres in the femoral flexion facets [12].

5.3 Patellar Instability

5.3.1 Pathology and Diagnosis

The term patellar instability has been used in different contexts in the literature including abnormal tilting or positioning of the patella

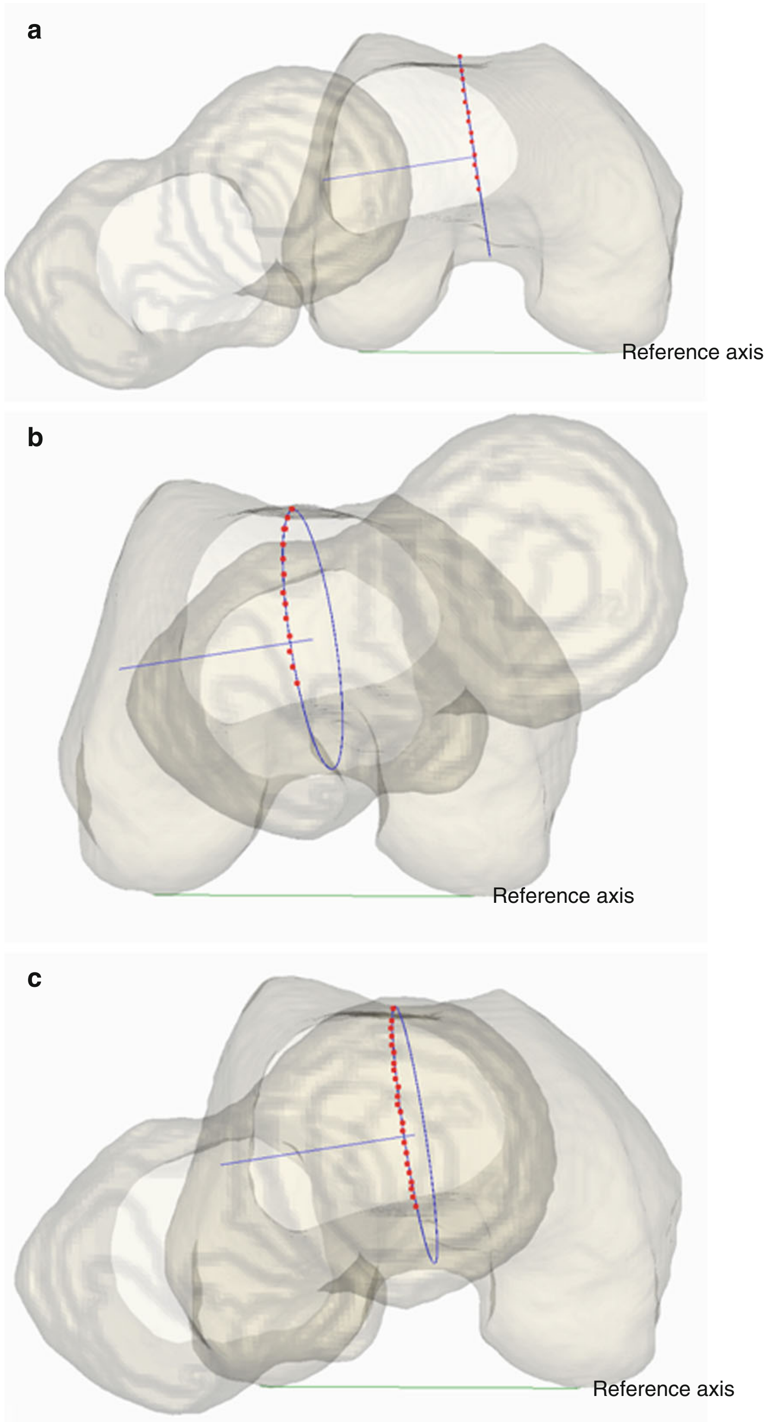

Fig. 5.1 Panels (**a**–**c**) demonstrate the effect of the femoral frame of reference on describing trochlear groove

[36, 37] but is here used to describe persistent maltracking which is associated with episodes of symptomatic subluxation or dislocation. Instability and malalignment of the patellofemoral joint are major causes of knee symptoms in young people [20, 22, 38].

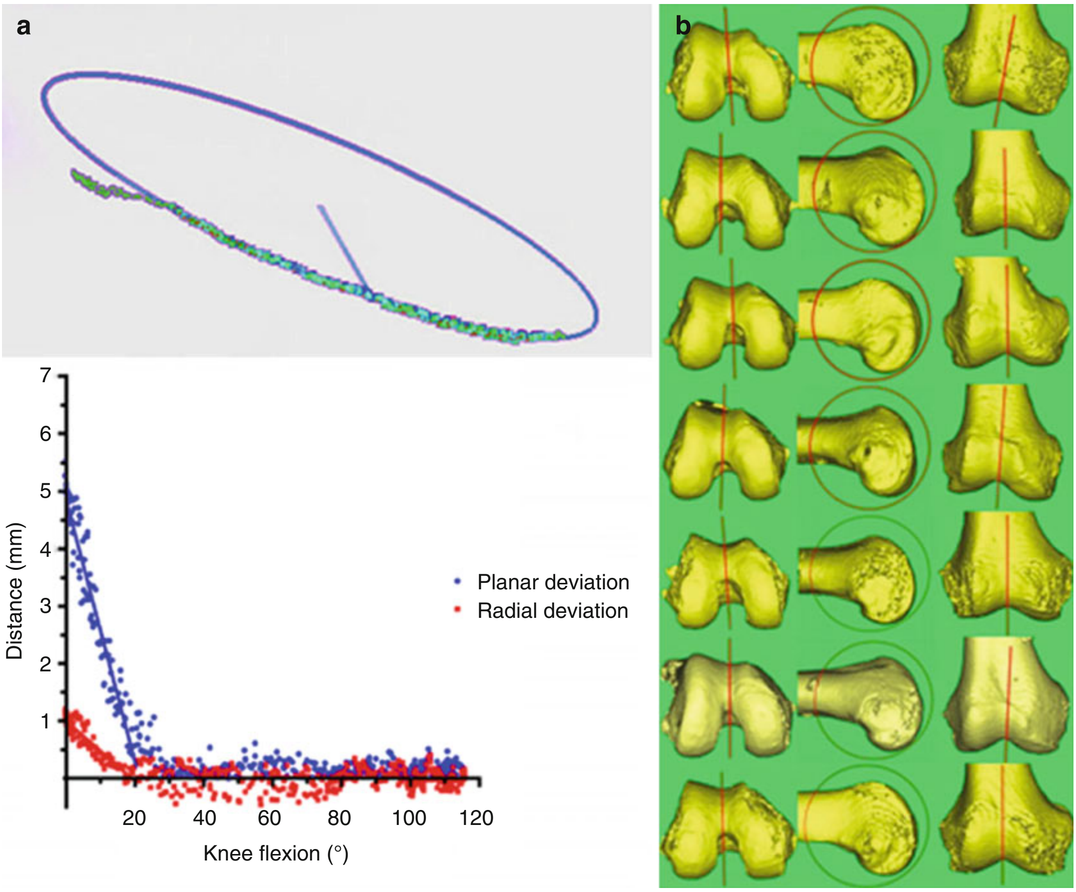

Fig. 5.2 (**a**) The moving landmark of the patellar centre during knee flexion for one knee is visualised and a best-fit circle is constructed to these points. The deviation from this circle is plotted against the knee flexion angle for two flexion-extension cycles. A *line* fitted to the graph crossed the x-axis at the flexion angle at which the path of the centre of the patella deviated from the circle. (**b**) The *circle* fitted to the path of the patella is illustrated in transverse, sagittal and coronal views

In full extension, the patella lies above the trochlea, and it is in early flexion that it articulates first at the distal pole and facets. As flexion progresses, contact occurs more proximally on the patella (and distally on the trochlea). Therefore, the contact surfaces and pressure on patellar facets changes throughout the range of motion, increasing the stabilising forces through the range of knee flexion [39].

Stability is provided by both bony and soft tissue stabilisers [8] and correlates with the geometry of the distal femur [40]. In the clinical evaluation of patellar tracking, it has been recommended that the patella is observed as it enters the femoral trochlear groove. In normal tracking, the patella moves smoothly into the femoral trochlea during initiation of flexion, and in terminal extension, there is minimal lateral displacement seen as the patella leaves the trochlea and occupies a supracondylar position. Exaggeration of this normal motion can be seen subjectively during clinical examination in the J-sign during initiation of flexion in patients with instability (see Chap. 1). This refers to the inverted “J” course of a patella that begins lateral to the trochlea then moves suddenly medially to enter the trochlea [41]. Although other patellofemoral pathological signs can be common in asymptomatic knees, the J-sign is almost universally associated with pathology [42]. A strong correlation has also been demonstrated between the presence of patellar tilt during clinical examination and tilt seen on magnetic resonance imaging (MRI) scans, such that patients with significant tilt on the physical examination can be expected to have an MRI tilt of 10° or greater whereas an angle of less than 10° is associated with the absence of significant tilt on the physical examination [38].

5.3.1.1 Bony Stabilisers

An increased trochlear sulcus angle is related to clinical instability [43]. Plain axial radiographs require accurate positioning [44, 45] and the true sulcus angle is difficult to measure as the "skyline" profile of the patellar contact area on the femoral groove changes with knee flexion [10]. Nevertheless, a degree of trochlear dysplasia can be seen in 85 % of patients with patellofemoral instability [46]. Lateral knee radiographs have also been used to describe abnormalities in the proximal-distal position of the patella relative to the knee [47–50]. The early part of the flexion cycle is critical because this is when the patella enters and engages the trochlear groove of the femur [51] and hence patella alta is related to instability [52, 53]. However, radiographic ratios of patellar position have significant inter-observer variability and rotational alignment of the knee affects these measurements [54].

Both computed tomography (CT) and MRI improve on the limitations of radiographs and are better at visualising the joint in early flexion. It is also possible to use newer techniques such as kinematic CT and MRI examinations to measure patellar tilt and translation in a moving knee [55–58]. However, the quadriceps muscles are relaxed during supine imaging and this may have an effect on the measurements [59]. In cadaveric studies, it has been shown that surgically flattening the lateral condyle can reduce the lateral stability of the patellofemoral joint [8] and that surgically flattening the anterior trochlea then subsequently deepening the sulcus with trochleoplasty caused decreased and then increased lateral patellar stability respectively [60].

5.3.1.2 Soft Tissue Stabilisers

The medial patellofemoral ligament (MPFL) provides 60 % of the medial stabilising force with a smaller contribution from the other components medial retinaculum [61]. There is also a dynamising effect of the vastus medialis obliquus muscle (VMO) on the MPFL [62, 63].

5.3.2 Treatment

The first line of treatment of patellofemoral instability involves physiotherapy with strengthening of the quadriceps focusing on the VMO, although it is debatable whether this can be selectively isolated in practice [64, 65]. For patients without overt dysplasia, physiotherapy remains a good option [66] and newer techniques, such as biofeedback, can improve the results [67].

Lateral patellar dislocation is associated with MPFL rupture in 87–100 % of patients [36, 68–70] and in the longer term, patellar instability and dislocation are associated with chondral injury and osteoarthritis [69, 71]. Non-operative management may leave a third of patients with significant symptoms, two fifths with at least one episode of further dislocation and half unable to return to vigorous sports at long-term follow-up [70]. Surgery can correct recurrent dislocation which without treatment can occur in 42–49 % of patients [70, 72].

Surgical treatment must depend on the primary pathology and identification of this pathology is mandatory for successful treatment of instability. Repair or reconstruction of the MPFL is indicated when soft tissues rather than bony morphology are the primary pathological feature [73–77]. Tibial tubercle advancement transfer [53, 78–80] or sulcus deepening trochleoplasty [81, 82] are considered favourable treatments for pathoanatomy such as increased tibial tubercle to trochlear groove (TT-TG) distance or trochlear dysplasia respectively [83, 84]. Guided growth for deformity correction has been described [85] as instability can present prior to skeletal maturity although some surgeons will elect to wait until physes have closed to avoid complications such as growth arrest [86]. An isolated lateral ligamentous release will only work for a proportion of patients and has not shown as favourable results as the other options above [87] because it cannot alone resolve all of the causative factors listed. Further research is necessary to understand the best surgical treatment for patellar dislocation. A Cochrane review found only poor quality evidence supporting any surgical treatment for patellar instability, with no trials examining people with recurrent dislocations, which are those most likely to require surgical management [88].

5.4 Osteochondral Defects (OCD)

5.4.1 Pathology and Diagnosis

Patellofemoral osteochondral defects can be associated with osteochondral or bone marrow lesions on imaging studies. MRI can be used to detect bone oedema even in the absence of fracture or defect on plain radiographs. OCD may be the precursor to patellofemoral arthritis although further research is required to determine the risk factors for progression to OA [89, 90]. Osteochondral injuries are associated with patellar instability and dislocation [91–93]. This is important as missed or delayed diagnosis can lead to chronic pain, decrease in sports, social and working activities, with the associated socio-economic impact, even when the primary pathology leading to the instability is addressed.

5.4.2 Treatment

Before the OCD itself can be treated, firstly the stability of the patellofemoral joint must be restored. As mentioned in the previous section, the medial retinaculum is injured with rupture in nearly all patellar dislocations [94] and this will impact the ongoing patellar stability and will compromise any reparative techniques for the cartilage.

Cartilage lesions are described in detail in Chap. 11. Compared to the tibiofemoral joint, and in particular to lesions in the femoral condyles, the shear forces encountered at the patellofemoral joint often render traditional reparative strategies, such as microfracture, unsuccessful. Modern techniques such as stem cell or chondrocyte implantation are showing promising early results [95] and matrix-induced autologous chondrocyte implantation (MACI) may offer an alternative solution in experienced hands [96, 97]. With ongoing technological progress, the high costs of such procedures may continue their downward trend but in areas of larger cartilage defects there are proponents for alternatives such as inlay arthroplasty [98] or osteochondral allograft transfer [99].

5.5 Patellofemoral Osteoarthritis (OA)

5.5.1 Pathology and Diagnosis

Isolated symptomatic patellofemoral osteoarthritis has been reported in 2 % of men and 8 % of women older than the age of 55 [100] and a prevalence of 9 % was noted in a series of 174 patients presenting to an orthopaedic a single centre with knee pain [101]. The aetiology of patellofemoral joint (PFJ) OA can be divided into surface pathomorphology and soft tissue imbalance. Evidence of trochlea dysplasia has been shown in 78 % of knees with isolated patellofemoral arthritis [102, 103]. The same factors implicated in patellar instability can predispose to OA: the extensor mechanism can be affected by excessive Q-angle [104], patella alta and tibial tubercle malposition [105]. A laterally positioned tibial tubercle [106, 107] and valgus alignment have been associated with PFJ OA [20, 107–109].

5.5.2 Treatment

Physiotherapy to strengthen the quadriceps muscles has been shown to be beneficial [110].

Lifestyle measures including activity modification and weight loss should also be considered key parts of treatment, particularly for patients with malalignment [111].

Surgical treatments include tibial tubercle elevation, total knee arthroplasty and patellectomy [112–114] although the latter has been much debated [115] and has now largely fallen from favour due to associated loss of extension power [116]. Newer options such as chondrocyte implantation are also being used in PFJ OA [117] although this is a developing field with only early results.

Arthroplasty interventions are beyond the scope of this book but will be dealt with briefly. Total knee arthroplasty (TKA) has had good results although it requires more soft tissue releases for isolated PFJ OA compared to tricompartmental knee OA [112]. One of the main issues with the patellofemoral articulation in TKA may be the design of the trochlear groove [118]. Patellofemoral joint replacement is a bone preserving procedure [119] and has gained popularity in treating isolated PF osteoarthritis in young patients [120–123]. Although early designs suffered from higher revision rates of up to one third, this has now improved dramatically [124], with some surgeons reporting no revisions at 5 years follow-up in a group of 50 patients [125]. The most common cause for revision was progression of tibiofemoral arthritis [126] although significantly less frequently when the patellofemoral arthritis had been secondary to femoral trochlear dysplasia [127]. Patient selection is of paramount importance and younger patients, those with dysplasia or previous patellofemoral trauma are the most suitable candidates as opposed to those with idiopathic arthritis or disease in other compartments [119, 128]. Patellofemoral joint replacement is a complex procedure as not only is the pathomorphology varied as discussed above but also placing even a well designed prosthesis correctly is challenging. Most femoral implant designs show characteristics of trochlear dysplasia [129, 130] and traditional surgical instruments allow significant variability in implant positioning. Patient-specific implants [131] and computer-assisted patellofemoral arthroplasty with preoperative planning [132] may improve component placement and accurate restoration of joint surfaces.

Conclusions

Patellofemoral disease has traditionally been less well understood compared to conditions affecting the tibiofemoral articulation and procedures performed at the patellofemoral joint have generally been more challenging compared to the rest of the knee. A thorough understanding of the mechanics of the joint and the pathophysiology of patellofemoral disease are vital to successful treatment. Fortunately, a great deal of research has been performed in this area in recent years and surgeons now have greater tools at their disposal for treating the three interlinked pathologies which primarily affect the patellofemoral joint.

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