Patellofemoral joint osteoarthritis: an important subgroup of knee osteoarthritis

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Knee osteoarthritis (OA) is a prevalent disease afflicting elderly people. As the knee joint is tri-compartmental, numerous radiographic patterns of disease are possible. The patellofemoral joint (PFJ) is one of the most commonly affected compartments. Although PFJ OA is frequently observed, this particular disease sub-group has gone largely unrecognised. Recent research suggests that not only is the PFJ an important source of symptoms in knee OA, but also that afflicted individuals demonstrate disease features distinct from those observed in tibiofemoral joint OA. This has implications for the assessment and treatment of patients with PFJ OA. This review summarises the evidence suggesting why PFJ OA should be considered a distinct clinical entity and how it may best be managed using conservative, non-pharmacological treatment approaches that are targeted to the PFJ. Interventions such as patella taping, patella bracing and physiotherapy have the potential to alleviate joint stress and symptoms for people with this condition.

KEY WORDS: knee, osteoarthritis, patellofemoral joint.

Introduction

Knee osteoarthritis (OA) is a chronic joint disease affecting one-third of elderly people [1]. The disease impacts upon activities of daily living (e.g. walking, stair-climbing and housekeeping), ultimately leading to a loss of functional independence and quality-of-life. As there is no cure for the condition and a frequent treatment for end-stage disease is joint replacement surgery, the economic impact of knee OA is considerable. Current clinical guidelines recommend non-pharmacological strategies in the first-line management of OA symptoms [2, 3]. Given the heterogeneity of knee OA with regard to aetiology, clinical presentation and natural history, the guidelines emphasize the need to tailor interventions to individuals in order to optimize treatment outcome. Considering the tri-compartmental nature of the knee joint, and the unique functions of each, tailored treatment based on compartmental involvement may be appropriate. This review summarizes the evidence suggesting why patellofemoral joint (PFJ) OA should be considered a distinct entity and how it may best be managed using conservative, non-pharmacological approaches.

The PFJ compartment is frequently involved in the OA process

As the knee joint is tri-compartmental [PFJ, medial and lateral tibiofemoral joint (TFJ)], various radiographic patterns of knee OA are possible. Traditionally, knee OA has been viewed primarily as a disorder of the TFJ as radiographic assessment has tended to focus only on the antero-posterior X-ray, which does not image the PFJ. As the use of lateral and skyline X-rays has increased, so to have awareness of the PFJ’s involvement in the OA process. In fact, the PFJ is one of the most commonly affected compartments. Authors of a recent community-based study of knee OA observed a higher frequency of radiographic osteophytes in the PFJ compared with the TFJ compartment (218/334 vs 184/334, \( P < 0.01 \)) [4]. Whilst it is acknowledged that the presence of osteophytes alone does not necessarily equate to a diagnosis of OA [5], osteophytic change is typical of the pathological changes associated with OA. Another investigation in people with knee pain revealed the most common radiographic pattern to be combined TFJ and PFJ disease (40%, 314/777 subjects), followed by isolated PFJ OA (24%, 186/777), with isolated TFJ disease in only 4% (31/777) of subjects and the remaining 32% (246/777) demonstrating normal radiographs (\( P < 0.001 \)) [6]. These recent studies reflect the findings of earlier community-based [7] and hospital-based cohorts [8]. Despite the high prevalence of PFJ OA, relatively little research has been directed towards this specific disease entity. Highlighting the importance of PFJ OA is recent data demonstrating that the presence of PFJ OA at baseline predicts the progression of structural change in the TFJ compartment over 30 months [odds ratio (OR) 2.31, 95% confidence interval (CI) 1.37, 3.88, \( P = 0.002 \)] [9].

The PFJ is an important source of symptoms in knee OA

It appears that the PFJ compartment is an important source of symptoms associated with knee OA, and possibly more important than the TFJ. A large study evaluated the association between structural abnormalities on magnetic resonance imaging (MRI) and knee pain and stiffness in people with and without knee OA [10]. Osteophytes in the PFJ were significantly associated with knee pain (OR 2.25, 95% CI 1.06, 4.77, \( P = 0.005 \)), whereas osteophytes in the TFJ compartment were not (OR 1.19, 95% CI 0.46, 3.09, \( P = 0.64 \)). These results are supported by Hunter et al. [11] who conducted a cross-sectional study evaluating the association between knee symptoms and MRI cartilage volume in 133 female participants. They found that reduced patella cartilage volume was associated with increased pain, function and global WOMAC scores. In contrast, neither femoral nor tibial cartilage volume was strongly associated with WOMAC scores. Furthermore, a recent radiographic study in patients who had undergone meniscal resection many years earlier found that individuals with combined PFJ and TFJ OA had more symptoms, lower function in sports and recreation and worse knee related quality-of-life than individuals with isolated TFJ OA [12]. Other authors [13–15] have also reported a relationship between radiographic features of PFJ OA (osteophytes and/or joint space narrowing) and knee pain. In the study by Cicuttini et al. [14],...
the strongest relationship was observed for osteophytes on the skyline X-ray (i.e. PFJ compartment). Another radiographic study demonstrated that PFJ OA has a greater association with disability than medial TFJ disease [7]. Thus, evidence from cross-sectional radiographic and MRI studies demonstrates that the PFJ compartment contributes to the symptoms of knee OA, and in fact, may be more important than the TFJ compartment.

**Patella cartilage differs from that of the TFJ**

Patella cartilage exhibits distinct biochemical and mechanical properties compared with that of the tibia and femur. Femoral and tibial cartilage demonstrates less *in vivo* deformation than patella cartilage with weight-bearing loaded activities [16]. *Ex vivo* measurement of cartilage mechanical properties has shown that femoral cartilage has a higher compressive aggregate modulus and lower permeability than patella cartilage [17]. Femoral cartilage water content is lower than that of the patella, whilst its proteoglycan content is higher. Serum cartilage oligomeric matrix protein concentration, a biomarker of cartilage damage/loss, is higher in patients with TFJ OA than in patients with PFJ OA of similar severity [18]. This may indicate qualitative differences in cartilage metabolism between the two. A 2-yr longitudinal study in knee OA patients has demonstrated that, although cartilage loss in the medial and lateral TFJ compartments is positively correlated, there is a poor association between cartilage loss in the PFJ compartment and that of the TFJ [19], lending support to this hypothesis. Similar results have been found in healthy people [20]. Furthermore, unlike tibial cartilage, patella cartilage volume is not related to bone mineral density [21]. Thus, it appears that factors influencing the development and maintenance of patella cartilage differ from those important for tibial cartilage.

**Biomechanics of the PFJ are unique**

Both systemic and local factors have been linked to the pathogenesis of OA and evidence from several studies suggests that risk factors may differ between the PFJ and TFJ compartments [22, 23]. The biomechanics of the PFJ are unique and distinctively different to that of the TFJ and the factors influencing the magnitude and distribution of PFJ pressure have important pathogenetic implications.

The PFJ reaction force is the measure of the compression of the patella against the femur. During weight-bearing activities, it is the vector summation of the quadriceps muscle and patellar ligament forces and hence any increase in knee flexion will heighten the PFJ reaction force [24, 25]. The PFJ reaction force can reach more than three times body weight during stair ascent and descent and seven to eight times body weight during squatting activities [26]. An important contributor to the distribution of the PFJ reaction force is the alignment and motion of the patella within the femoral trochlea. PFJ malalignment leads to increased contact pressure on an individual facet (e.g. a lateral tilt of the patella leads to increased contact pressure on the lateral facet). Optimal alignment relies on complex inter-relationships of many local joint structures and lower limb alignment [27]. At a local level, patella alignment relies on passive (ossueous configurations and soft-tissue restraints) and active (medial and lateral quadriceps) structures. The ossueous anatomical anomalies most likely to affect the alignment and motion of the patella are a shallow femoral trochlea groove depth [28] and patella alta [29]. Soft tissue tensions; medial and lateral retinaculae, particularly the two distal expansions of the iliotibial band [30], the joint capsule and ligaments all contribute to maintaining patella alignment [31]. The quadriceps muscles essential to optimal patellar alignment are the vastus medialis obliquis (VMO), the more distal portion of the medial quadriceps, and the vastus lateralis (VL) [32]. Healthy older individuals have been found to exhibit synchronous VMO and VL activity during a variety of activities [33–35]. Experimentally induced (using cadaveric or biomechanical models) reductions in VMO activity or increases in VL activity result in lateral patella malalignment and heightened lateral PFJ contact pressure [36, 37]. Younger patients with PFJ pain have demonstrated a delayed onset of VMO activity relative to the VL during a monosynaptic reflex (patellar tap) [38], during isokinetic knee extension [39, 40] and during a stair-stepping task [41, 42]. Whilst people with generalized knee OA do not exhibit a delayed onset of VMO relative to VL [33–35], it is possible that a delay may be evident in people with PFJ OA, although this patient group has not been evaluated to date.

Lower limb alignment may affect patellar tracking by altering the relative position of the femoral trochlea and changing the tension in soft-tissues. Notably, experimentally induced femoral internal rotation or tibial external rotation have been associated with increased lateral patellar tilt and rotation [43] and increased lateral PFJ pressure [44]. The Q angle (formed by the intersection of the line of application of quadriceps force with the centre line of the patellar tendon) is a clinical measure of lower limb alignment that represents the resultant force orientation of the four components of the quadriceps muscles acting on the patella in the frontal plane [45, 46]. This laterally directed force vector results in the lateral patellar facet receiving 60% more force than the medial facet [47]. Experimental increases in the Q-angle shifts the PFJ contact area laterally and further increases pressures within the lateral facet [45, 46, 48]. While it is likely that lower limb alignment, in particular Q angle, tibial external rotation and femoral internal rotation or anteverision, can affect patellar alignment, there is a paucity of studies that have investigated this hypothesis.

Small alterations in force (lateralization or increase in force) or in contact area (lateral patella malalignment) will significantly impact on the contact pressure on the lateral facet, which is reflected in the disease pattern in this joint, with the lateral compartment being predominantly affected by the OA process [49, 50]. Among 96 knees with asymmetric PFJ space narrowing, 75 (78%) had evidence of greater lateral PF narrowing [49]. Not surprisingly, lateral PFJ OA radiographic progression is more common than medial PFJ OA [51].

In contrast to the biomechanics of the PFJ, the factors influencing the distribution and magnitude of TFJ force are specific to that compartment. During walking, the ground reaction force vector passes medial to the knee joint centre, creating an external adduction moment about the knee. The adduction moment determines load distribution across the medial and lateral tibial plateaus, with force across the medial compartment almost 2.5 times that of the lateral [52]. This may explain why medial TFJ OA is more prevalent than lateral TFJ OA [7, 8]. Varus knee malalignment, which typically accompanies a loss of joint space in medial TFJ OA, serves only to increase the moment arm of the force vector, thereby increasing the adduction moment [53]. As it has been shown that an increased adduction moment at baseline increases the risk of structural disease progression in the TFJ compartment over time [54], there is presently much emphasis on the design and evaluation of interventions that can reduce this parameter. Interventions such as laterally wedged shoe insoles and varus knee bracing offer great potential in the management of medial TFJ OA, given their minimizing effects on the knee adduction moment [55, 56]. However, it is likely that such interventions are sub-optimal and may in fact be detrimental for PFJ OA given the features of the disease.

**Features of PFJ OA differ from those of TFJ OA**

Although available evidence is limited, it appears that individuals with PFJ OA manifest features and physical impairments that differ sufficiently from individuals with TFJ OA to warrant targeted intervention. Clinically, patella malalignment within the femoral trochlea is commonly exhibited by patients with PFJ OA, yet few studies have evaluated this relationship.
Patellofemoral osteoarthritis

Patella malalignment typically manifests as lateral patellar tilt, lateral displacement or a combination of the two (Fig. 1). Although only reported in abstract form, a study of Beijing residents found that knees with a more laterally positioned patella and greater patella tilt laterally demonstrate a higher prevalence of PFJ OA [57]. Furthermore, work by the same authors in Caucasian and African-American people shows that patella subluxation is associated with knee pain severity and risk of disease progression [58]. The congruence angle, a measure of patella subluxation, correlates with severity of radiographic PFJ OA, such that disease severity increases when the patella is subluxed either medially or laterally [59]. Medial subluxation is predominantly associated with medial PFJ OA, whilst lateral subluxation primarily manifests arthritic change in the lateral compartment. Patella subluxation appears to be common, with 20 and 28% of varus knees demonstrating medial and lateral displacement, respectively, and 47% of valgus knees demonstrating lateral displacement [59]. Iwano et al. [50] also undertook a radiographic study of patella position in 108 knees with moderate to severe PFJ OA. They found significantly greater lateral tilt of the patella in patients with isolated PFJ OA compared with those with concurrent TFJ OA (11.1° vs 7.8°, respectively, P < 0.02).

Interestingly, 28% of the patients with isolated PFJ OA reported a history of patella dislocation/subluxation, compared with none of the patients with combined PFJ/TFJ OA [50], suggesting that a history of patella dislocation/subluxation may be a predisposing factor for PFJ OA. Given that lateral patellar subluxation is associated with a 50% reduction in and a lateralization of the PFJ contact area [48] resulting in an increase in lateral PFJ stress, treatment strategies aimed at normalizing patella alignment may be of particular importance in PFJ OA.

Varus-valgus knee alignment also appears to differ according to which knee compartment is affected by OA. A cross-sectional study compared alignment in patients with isolated moderate–severe PFJ OA to those with isolated TFJ OA of similar severity [49]. Valgus malalignment was present in 63% of patients with isolated moderate–severe PFJ OA but in only 26% of the TFJ OA patients (the remainder of whom were varus). As frontal plane alignment is a determinant of the Q-angle, valgus malalignment leads to an increase in the Q-angle and thus increased stress on the lateral patella facet. Although it is not clear whether valgus alignment precedes PFJ OA, a subsequent study demonstrated that valgus knee alignment at baseline was associated with a 1.6 increase in the odds of isolated lateral PFJ OA progression over 18 months [51].

Muscle weakness, particularly affecting the quadriceps, is a key feature of TFJ OA. Quadriceps strength is a determinant of both pain severity and physical function in patients with TFJ OA [60], and there is some evidence that quadriceps weakness may precede the development of the disease [61, 62]. Although likely that muscle weakness accompanies PFJ OA, it is unclear which muscles are primarily affected, as few studies have specifically compared lower limb muscle strength in patients with PFJ OA to either those with TFJ disease or alternatively, to a healthy control group. Although there is a relationship between quadriceps weakness and knee OA in all compartments [63], evidence suggests that quadriceps strength may play a more important role in TFJ OA. Longitudinal data demonstrate that greater strength increases the likelihood of TFJ disease progression in malaligned or high-laxity knees, but does not alter the probability of progression within the PFJ compartment [64]. Given that balanced activity in the medial and lateral quadriceps is essential in maintaining PFJ alignment, it is possible that alterations in either the magnitude and/or timing of activity in these muscles is more important in PFJ OA than overall quadriceps strength per se. Whilst patients with mixed TFJ/PFJ OA do not demonstrate alterations in the timing of medial and lateral quadriceps activity [65], no research has evaluated muscle recruitment patterns in patients primarily selected on the basis of PFJ involvement.

Implications for assessment and management

PFJ OA is characterized by a stereotypical group of signs and symptoms and therefore diagnosis is generally made by clinical presentation, in the presence of radiographic changes. The pattern of knee pain is similar to patients with patellofemoral pain, either localized to the retropatella region, or more commonly diffuse, encompassing the regions inferior, medial or lateral to the patella [66]. Less commonly, the pain is perceived lateral to the patella or on the posterior aspect of the knee. The clinical diagnostic test that appears to have uniform acceptance, despite lack of validation, is the presence of tenderness on palpation of the patella facets. Symptoms are typically aggravated by activities that load the PFJ (i.e. stair ambulation, rising from sitting, kneeling and squatting).

Clinical assessment should evaluate features that may be contributing the aetiology of PFJ OA. Patella alignment may be visualized from computerized tomography or MRI axial scans, or in the clinical setting a tape measure may be used [67]. Quadriceps muscle strength can be assessed manually, or using hand-held dynamometry [68]. Although accurate assessment of medial and lateral quadriceps activity can only be performed with sophisticated laboratory equipment, surface EMG biofeedback units (especially those which have dual channels) can provide useful information on their relative contribution. While no objective measures of femoral and tibial rotations during dynamic activities are available in the clinical setting, observation of gait and other functional activities (stair ambulation and squatting) may assist the clinician to determine the contribution of lower limb alignment to their patient’s condition.
Although clinical guidelines emphasize the need to individualize OA management strategies in order to optimize outcome [2, 3], and treatment based on compartmental patterns of disease is a logical choice, little research has evaluated conservative interventions specifically for patients with PFJ disease. Most clinical trials to date have regarded patients with knee OA as a homogenous group. Participants have generally been selected on the presence of non-specific knee pain and radiographic changes indicating OA in the knee joint, often observed on an antero-posterior X-ray only. Few, if any, authors have actually evaluated the PFJ compartment specifically, either to determine patient selection or to evaluate treatment responsiveness according to radiographic presentation. Thus, in contrast to TFJ OA, there is little evidence presently guiding the conservative non-pharmacological management of PFJ OA.

With the exception of patella re-surfacing by surgical means, patella taping is the only intervention aimed specifically at PFJ OA [69]. In a small cross-over study of 14 patients with narrowing and osteophytes in the PFJ (predominantly lateral compartment), taping the patella in a medial direction for 4 days resulted in a 25% reduction in knee pain. A subsequent randomized controlled trial (RCT) later confirmed the efficacy of knee taping for reducing pain and disability in 87 patients with mixed knee OA, the majority of whom demonstrated some degree of PFJ involvement [70]. However, the patients in this RCT were neither selected on the basis of PFJ OA nor on the pattern of presenting knee pain, thus it is likely that patella taping may have an even greater effect on symptoms in patients with predominant PFJ OA and anterior knee pain, than that observed in this study. Although it is not clear how patella taping achieves its pain-relieving effects in OA, it is possible that subtle changes in patella position alter the magnitude and/or distribution of PFJ stress, but this has not been evaluated in a population with PFJ OA. Another conservative means of altering patella position is by the use of knee bracing. Valgus knee braces are useful in TFJ OA, as research demonstrates they can significantly reduce the knee joint adduction moment, as well as alleviate symptoms [56, 71]. Whilst such braces are unlikely to offer any benefit for patients with PFJ OA, patella stabilizing braces offer promise. Patella stabilizing braces are similar to taping, in that they aim to re-position the patella medially and reduce joint stress. In younger patients with patellofemoral pain syndrome, patella stabilizing braces have been shown to reduce knee pain, as well as PFJ stress [72, 73], mostly through increasing PFJ contact area. As they have not been evaluated in patients with PFJ OA, it remains to be seen how effective patella stabilizing braces are in the management of this condition.

Given that PFJ OA is frequently associated with valgus knee joint malalignment, it is possible that interventions designed to correct frontal plane alignment may be beneficial in the reduction of symptoms and/or lateral PFJ compartment stress in these patients. Accordingly, knee braces that realign the knee joint in a varus direction (as opposed to those that realign in a valgus direction and are used for medial TFJ disease) warrant investigation for their potential clinical application in PFJ OA. Another intervention hypothesized to alter knee alignment are wedge orthotics. Theoretically, angulation of the calcaneum induced by insertion of a wedge orthotic in the shoe may alter alignment of the knee in the frontal plane. Laterally wedge orthotics are advocated for the management of medial TFJ OA, and are proposed to reduce varus malalignment. Although research is inconclusive regarding their effects on alignment, laterally wedge orthotics have been shown to reduce the knee adduction moment and pain in patients with medial TFJ OA [55, 74]. If able to realign the knee in a varus direction, it is possible that mediolaterally wedge orthotics may be beneficial for PFJ OA, however they have not been evaluated in this patient group.

Whilst physiotherapy treatment is recommended for patients with OA [2, 3], only one physiotherapy intervention has been specifically designed for patients with PFJ OA [75]. This RCT involved 87 people with chronic knee pain and radiographic evidence of PFJ osteophytes in the absence of advanced TFJ OA. The physiotherapy intervention comprised an exercise program aimed at strengthening the quadriceps, in particular its medial components, medial patella tapping, postural correction of lower limb alignment and footwear advice. Compared with the control group who received no intervention, physiotherapy only demonstrated improvements in pain and quadriceps strength 10 weeks after treatment had ended, with no differences between treatment groups evident at 12 months. A number of limitations to this study exist which may explain these surprising results. First, patients were not re-assessed immediately after treatment had ceased but 10 weeks later, thus immediate treatment effects may have been missed. Secondly, patients were not selected on the location/nature of their knee pain. It is possible that some patients may have had symptoms that were not emanating from the PFJ, and thus were unlikely to benefit from such a specific intervention. Thirdly, the patella tape was largely applied by the patients rather than physiotherapists, and it is presently unknown whether patients are able to tape their knee as effectively as a physiotherapist. Finally, it is not clear how compliant patients were with the exercise program. Rather than being considered conclusive, results of this study should be used to refine treatment protocols and patient selection criteria for future research evaluating physiotherapy for PFJ OA.

Conclusions

Knee OA imposes a significant burden on afflicted individuals and society as a whole. Although under-researched relative to the TFJ, the PFJ compartment is frequently afflicted by the disease process and PFJ OA is associated with considerable pain and disability. It is likely that clinical outcome for PFJ OA will be optimized if conservative non-pharmacological treatment strategies consider the unique biomechanical functions of the PFJ and the specific impairments associated with disease in this compartment, which differ from those associated with TFJ OA. Patella taping, bracing and physiotherapy are interventions that all offer potential in the alleviation of symptoms and/or reduction of PFJ stress in patients with PFJ OA.

**Rheumatology key messages**

- PFJ OA is common and a significant source of symptoms.
- Targeted interventions for PFJ OA are required because of the differences between this compartment and the TFJ.

The authors have declared no conflicts of interest.

**References**


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