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Review

# Which patellofemoral joint imaging features are associated with patellofemoral pain? Systematic review and meta-analysis

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SUMMARY

*Objectives:* To review the association between patellofemoral joint (PFJ) imaging features and patellofemoral pain (PFP).
*Design:* A systematic review of the literature from AMED, CiNAHL, Cochrane Central Register of Controlled Trials (CENTRAL), MEDLINE, PEDro, EMBASE and SPORTDiscus was undertaken from their inception to September 2014. Studies were eligible if they used magnetic resonance imaging (MRI), computed tomography (CT), ultrasound (US) or X-ray (XR) to compare PFJ features between a PFP group and an asymptomatic control group in people <45 years of age. A pooled meta-analysis was conducted and data was interpreted using a best evidence synthesis.
*Results:* Forty studies (all moderate to high quality) describing 1043 people with PFP and 839 controls were included. Two features were deemed to have a large standardised mean difference (SMD) based on meta-analysis: an increased MRI bisect offset at 0° knee flexion under load (0.99; 95% CI: 0.49, 1.49) and an increased CT congruence angle at 15° knee flexion, both under load (1.40 95% CI: 0.04, 2.76) and without load (1.24; 95% CI: 0.37, 2.12). A medium SMD was identified for MRI patella tilt and patellofemoral contact area. Limited evidence was found to support the association of other imaging features with PFP. A sensitivity analysis showed an increase in the SMD for patella bisect offset at 0° knee flexion (1.91; 95% CI: 1.31, 2.52) and patella tilt at 0° knee flexion (0.99; 95% CI: 0.47, 1.52) under full weight bearing.
*Conclusion:* Certain PFJ imaging features were associated with PFP. Future interventional strategies may be targeted at these features.
*PROSPERO registration number:* CRD 42014009503.


## Introduction

Patellofemoral pain (PFP) refers to pain experienced either from the anterior or retro-patellar region and typically occurs in adolescents and younger adults[1]. Knee pain affects up to 30% of adolescents[2] with as much as 50% attributed to PFP[3]. Whilst one in six adults consulting their general practitioner with knee pain will be diagnosed with PFP[4]. Currently, unfavourable recovery rates in PFP are known to be as much as 40% up to one year following treatment[5]. The degree of unfavourable recovery is important given the growing concern that PFP, if not successfully managed, may be a potential precursor to patellofemoral osteoarthritis (PFOA)[6].

The exact pathogenesis of PFP remains unknown and thus its management remains inconsistent[7]. Many factors have been previously associated with PFP, including biomechanical, structural and clinical features[7]. It is widely believed that abnormalities of the structure and the function of the patellofemoral joint (PFJ) is the underlying cause of PFP[8]. The prevailing theory is that PFP is caused by abnormal tracking and alignment of the patella leading to irritation of richly innervated PFJ structures like subchondral bone, lateral retinaculum or synovium[9]. The structure of the PFJ has more recently become the subject of increased interest since the PFJ was established as the most common compartment for knee OA[10,11].

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Currently there is a paucity of evidence to support the link between PFP and PFOA[12], however, reported similarities in their clinical impairments and functional limitations, such as stair descent, would infer a relationship[6]. Furthermore, Utting *et al.*[13] reported that over 20% of people undergoing surgery for isolated PFOA recalled experiencing PFP symptoms as an adolescent.

Historically, the PFJ has been visualised using X-rays in a static, non-weight bearing position. Over the last 20 years, imaging has revolutionised the understanding of the knee as a whole[14] with advances in structure visualisation, kinematic applications and loading capabilities[15]. More recently, a variety of modern imaging modalities have been used to assess PFJ structure[16], but no consensus exists on which of these image modalities should be used or the key features to image.

This systematic review aimed to establish which PFJ imaging features are associated with PFP compared to asymptomatic individuals.

## Methods

### *Protocol and registration*

This systematic review was performed using a predetermined protocol in accordance with the PRISMA statement[17]. The study protocol was registered with PROSPERO, registration number CRD 42014009503.

### *Search strategy and study selection*

A primary electronic search of AMED, CiNAHL, Cochrane Central Register of Controlled Trials (CENTRAL), MEDLINE, PEDro, EMBASE and SPORTDiscus was undertaken from their inception to September 2014. Additionally, a secondary electronic search of unpublished and trial registry databases was performed. This included: OpenGrey, the WHO International Clinical Trials Registry Platform, Current Controlled Trials and the UK National Research Register Archive. The electronic search was complemented by hand searching the references of the retrieved articles. The search terms used for Medline (also used for the other databases) are in Supplementary Material.

### *Eligibility criteria*

The selection of studies was made using the titles and abstracts, independently screened by two reviewers (BD, FP). Potential studies had the full text retrieved and were screened against the eligibility criteria. Studies were eligible if: (1) they included human participants under 45 years (mean age of participants) diagnosed with PFP; (2) magnetic resonance imaging (MRI), computed tomography (CT), ultrasound (US) or X-ray (XR) was used to image the PFJ and local structures; (3) a comparison of PFP cases and a healthy control group was provided; (4) they were published in English. For the purposes of this study, PFP was determined using previously published clinical criteria[18]. Studies that included participants diagnosed of PFP, anterior knee pain or chondromalacia patellae were all considered. If a study included participants with arthroscopically confirmed chondromalacia patellae outside the currently accepted clinical presentation of PFP[18] then these studies were excluded. Studies including other conditions such patella tendinopathy and patella dislocation were also excluded if the PFP could not be analysed separately.

Data extraction was initially piloted by two reviewers (BD, FP) before the formal extraction was undertaken. Two reviewers (BD, FP) then used a standardised, piloted form to extract data regarding study characteristics, participant characteristics, imaging procedures, settings and outcome data results. A third reviewer (TS) was used to resolve disagreements in eligibility, data extraction or quality assessment.

### *Quality assessment*

The methodological quality of the included studies was assessed by the same two reviewers (BD, FP). A modified version of the Down & Black's Checklist[19] was used with original 27 items reduced to 17 items as described previously[20] (Supplementary Material), as not all items were applicable for all non-randomised studies. All included studies were classified using the following quality rating bandings which have been used previously in conjunction with Downs & Blacks checklist[21]: low (<33.3%), moderate (33.4–66.7%) and high (≥66.8%)[22].

### *Data analysis*

Study heterogeneity was assessed using the extraction tables. If there were no heterogeneity between studies in relation to population, assessment procedure or outcome measurement method, a meta-analysis was conducted to compare between case and control groups for each PFJ feature calculating the standardised mean difference (SMD). SMD was categorised as small (SMD ≥ 0.2), medium (SMD ≥ 0.5) and large (SMD ≥ 0.8)[23]. Statistical heterogeneity was assessed using I-squared and Chi-squared tests. When I-squared was greater than 20% and Chi-squared less than $P = 0.10$, a random-effects model was used. When I-squared was less than 20% and Chi-squared was greater than $P = 0.10$, a fixed-effect model was adopted. When substantial heterogeneity was present, a narrative synthesis of the literature was presented. Both the narrative synthesis and the meta-analysis were interpreted using a best evidence synthesis[24] (Table I[25]) determined by the results of the risk-of-bias assessment and the methodological quality of the included studies[26,27].

## Results

### *Study selection*

Fig. 1 summarizes the results of the search strategy. The search identified 5,290 papers, with 3,852 after duplications were removed. Following screening of the title and abstract, 3,702 of these were excluded. Subsequent full text assessment identified 46 papers describing 40 studies. Five studies[28–38] reported the same

**Table I**
Best evidence synthesis

1.) Strong evidence is provided by generally consistent findings in multiple high-quality cohort studies.
2.) Moderate evidence is provided by general consistent findings in one high-quality cohort study and two or more high quality case–control studies or in three or more high-quality case–control studies.
3.) Limited evidence is provided by (general consistent) findings in a single cohort study, in one or two case–control studies or in multiple cross-sectional studies.
4.) Conflicting evidence is provided by conflicting findings (i.e., <75% of the studies reported consistent findings).
5.) No evidence is provided when no studies could be found.

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