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Location of knee pain in medial knee osteoarthritis: patterns and associations with self-reported clinical symptoms

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SUMMARY

Objectives: To (1) document pain location in medial tibiofemoral osteoarthritis (OA) using the patient-administered Photographic Knee Pain Map (PKPM); (2) compare pain severity, nature and likelihood of neuropathic-like symptoms, physical dysfunction and presence of symptoms at other sites across the most common pain patterns.
Design: Baseline data were analysed from 164 participants with medial tibiofemoral OA (TFJOA) participating in a randomised controlled trial (RCT). Participants completed the PKPM indicating all relevant pain zones of their most painful knee. Pain zones were collapsed into regions to determine patterns of pain. Symptoms were quantified using numeric rating scales (NRSs) of pain severity, Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), Intermittent and Constant Osteoarthritis Pain (ICOAP) and painDETECT questionnaires. Symptoms at other joints were categorised as present/absent.
Results: The medial joint line ($n = 123$, 75%), patellar tendon ($n = 62$, 38%) and posterior knee ($n = 61$, 37%) were the most frequently reported pain zones. The most frequent patterns were diffuse (41%), isolated medial (16%), anterior-medial (12%) and medial-posterior (11%) pain. WOMAC and ICOAP scores were higher in the diffuse compared to anterior-medial patterns. Mean PainDETECT scores were higher with both diffuse and medial-posterior pain relative to anterior-medial pain.
Conclusion: Only 16% of the cohort indicated isolated medial knee pain, whilst a diffuse pain pattern was most common. People with diffuse knee pain reported more severe pain and physical dysfunction than those with anterior-medial pain. Prevalence of possible/likely neuropathic-like symptoms tended to be more frequent in diffuse and posterior-medial patterns compared to anterior-medial pain.

Introduction

Knee pain is the most debilitating symptom of knee osteoarthritis (OA)[1–3]. Its aetiology is complex and clinical presentation heterogeneous[2–4]. For clinicians, pain location is a standard component of assessment to assist diagnosis of a clinical problem and to guide decision-making regarding the most appropriate treatment course. For researchers, pain location may be used as a selection criterion for a given study (e.g., medial knee pain to increase likelihood of recruiting those with medial tibiofemoral OA (TFJOA))[5–8]. Despite the plethora of research evaluating pain experiences associated with knee OA, there are relatively few studies evaluating location of pain[2,9–11].

Typically, location of knee pain has been ascertained using interviewer-administered proxy knee representations where the interviewer maps painful sites onto a diagram after the patient had described and/or pointed to the location(s) of pain[2,3,9,11–14]. Administrative burden aside, interviewer-mapped assessments may have limited accuracy because of interviewer errors and/or recall or coding bias[15]. Additionally, numerous diagrammatic knee representations have been used, which have not been validated and/or evaluated for reliability[2,9–11,14]. Although previous studies suggest that the anterior-medial and/or medial knee is a common

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site of pain in mixed compartmental knee OA[2,9–11], discrepancies in the literature remain as to whether pain is typically local in nature or more generalized[2,3,9,10]. Pain location appears to impact severity of pain and physical dysfunction in knee OA, as poorer clinical outcomes have been reported with more generalized pain patterns[3,9,10]. However the current literature is limited by the use of interviewer-dependent methods, and/or knee diagrams that fail to represent the entire knee. Furthermore, previous research on pain location in knee OA is largely limited to heterogeneous samples (including chronic knee pain patients with or without radiographic OA) rendering resulting patterns difficult to interpret and apply to clinical practice and/or research. Given that medial TFJOA is a common pattern of OA[16], research evaluating pain location in people with definite evidence of medial TFJOA is warranted. Further, no study in knee OA has evaluated relationships between pain location and neuropathic-like symptoms.

The Photographic Knee Pain Map (PKPM) was developed to overcome limitations of previous methods[15]. The PKPM provides a photographic representation of both knees. The patients themselves indicate pain locations in their knees by marking the relevant areas on the photographs with small crosses. Subsequently, researchers use a transparency template to overlay on the photographs mapping painful areas to distinct knee zones. This template identifies 10 zones with margins based on anatomic boundaries[15]. This patient-administered instrument has generally good to very good intra-rater and inter-rater reliability, and has demonstrated convergent validity against an interviewer-administered knee pain map[2] in patients with knee pathology[15]. Although the PKPM has been applied in a cross-sectional sample undergoing arthroscopy for a range of knee pathologies[17], it has not been used to identify pain location in knee OA.

The aims of this study were two-fold. Firstly, we aimed to describe locations and patterns of knee pain in people with radiographic medial TFJOA using the patient-administered PKPM. Secondly, we aimed to compare the differences in knee pain (severity, nature (intermittent or constant) and quality (possible/likely neuropathic-like symptoms)), physical dysfunction and presence of symptoms at other sites across the most common patterns of pain location to determine whether pain location is associated with clinical symptoms.

Materials and methods

This cross-sectional analysis utilized baseline data of an ongoing randomised controlled trial (RCT) evaluating the effects of unloading shoes in medial TFJOA[18]. Data for this cross-sectional study were collected at baseline in the RCT, prior to randomization.

Participants

Data from 164 participants with medial TFJOA enrolled in the RCT were used. Participants were recruited from the community via advertisements in social and print media, radio and television and our volunteer database. Medial TFJOA was classified according to American College of Rheumatology criteria[19]. Inclusion criteria were: (1) aged $\geq$50 years; (2) knee pain on most days of the past month; (3) average pain score of $\geq$4 on an 11-point numerical rating scale (Numeric rating scale (NRS), terminal descriptors 'no pain' and 'worst pain possible') in the past week; (4) definite X-ray evidence of OA (Kellgren–Lawrence (KL) $\geq$grade 2)[20]; and (5) definite X-ray evidence of medial TFJOA (at least grade 1 medial osteophytes and medial $\geq$ lateral osteophytes, and at least grade 1 medial joint space narrowing (JSN) and medial > lateral JSN) using a radiographic atlas[21]). Major exclusion criteria included: (1) intra-articular corticosteroid injections or knee surgery to either knee (past 3 months); (2) history of knee joint replacement or high tibial osteotomy; (3) systemic arthritic conditions; (4) any other muscular, joint or neurological condition affecting lower limb function; (5) a body mass index (BMI) $\geq$ 36 kg/m^2 (due to difficulties in three-dimensional gait analysis in the RCT) and/or; (6) ankle/foot pathology or pain that was either perceived as worse than knee pain and/or required treatment in the past 6 months[18].

For bilaterally eligible knees, only the most symptomatic knee was evaluated. If both knees were rated as equally painful, the right knee was evaluated. Ethics approval was obtained from The University's Human Research Ethics Committee. All participants provided written informed consent.

Radiographic evaluation

Radiographic severity of TFJOA was assessed from semiflexed posteroanterior weightbearing X-rays. The KL grade[20] was used to rate overall severity of TFJOA, where grade 2 = definite osteophytes and possible JSN, grade 3 = moderate multiple osteophytes, definite JSN and possible bone deformity and grade 4 = large osteophytes, marked JSN, severe sclerosis and definite bone deformity[20]. A radiographic atlas[21] was used to rate medial and lateral tibiofemoral JSN and each of medial and lateral tibial and femoral osteophytes (Grade 0 = normal, Grade 1 = mild, Grade 2 = moderate, Grade 3 = severe). Radiographs were evaluated by the same musculoskeletal researcher with >10 years of experience in grading radiographic knee OA (RSH). In our laboratory, we have previously reported intra-rater and inter-rater reliability of KL grades (weighted kappa) of 0.83–0.87 and 0.87, respectively[22].

Descriptive characteristics

Demographics were collected by questionnaire and included age, gender, duration of symptoms and previous knee surgery. Height and weight were measured to calculate BMI.

Knee pain location

The PKPM was used to determine location of knee pain[15]. Participants marked all pain locations in their most symptomatic eligible knee using small crosses upon a paper copy of a photographic representation of the anterior view of a pair of knees (Fig. 1). Additionally, a tick box below the photograph enabled participants to report pain in the posterior knee (as present or absent). Subsequently, a template transparency dividing the knee into nine anterior zones based upon anatomic landmarks (lateral and medial joint line areas, superior lateral and medial zone, quadriceps tendon, lateral and medial patella, patella tendon and tibia) was overlaid on the photograph [Fig. 2(A)]. For each zone, pain was recorded as present if one or more marks were located in the zone as per the bordering lines on the transparency. Marks located on bordering lines indicated pain in both adjacent zones. Thus, for each participant, pain was recorded as either present or absent in each of the 10 zones (nine anterior and one posterior zone)[15,17].

Clinical symptoms

The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) was administered to assess pain and physical function during daily tasks using the respective subscales. The pain subscale has five items with a five-point Likert response scale ('no pain' (score 0) to 'severe pain' (score 4)) and giving a maximum score of 20. The physical function subscale has 17 items with a five-point Likert response scale ('no physical dysfunction' (score 0) to

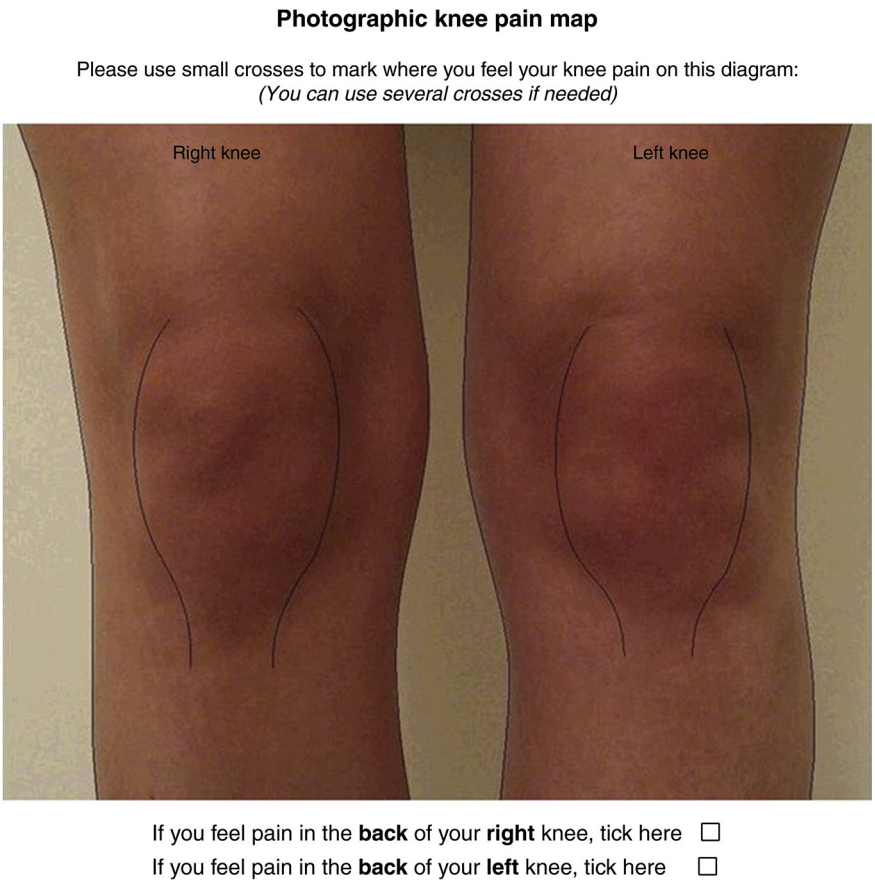

Fig. 1. The PKPM (with accompanying participant instructions) as administered to the participants[15].

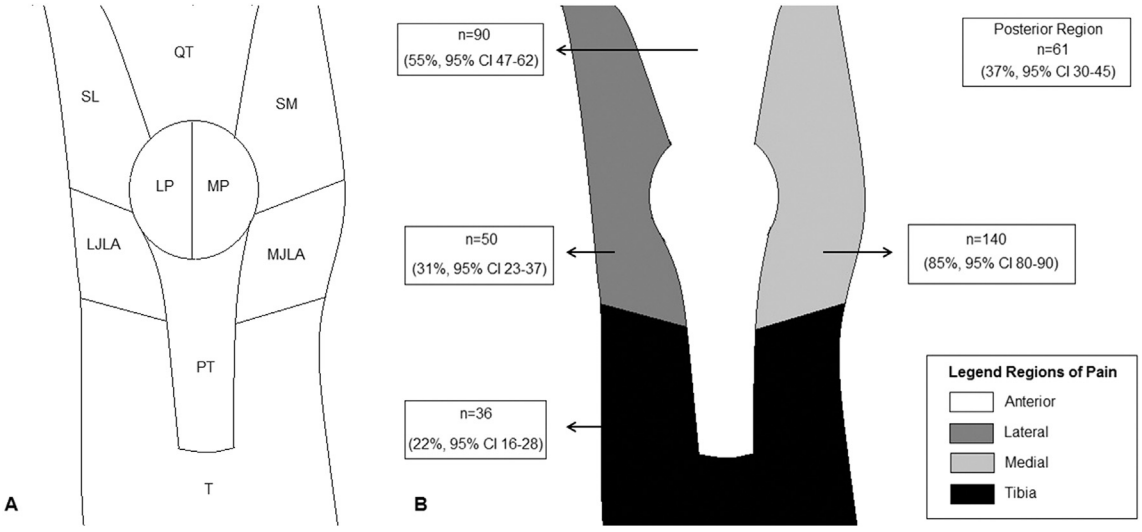

Fig. 2. A schematic representation of the knee pain zones identified using the overlay of the PKPM[15] (A) and how they were used to determine pain regions (B). QT = Quadriceps tendon, LP = Lateral Patella, MP = Medial Patella, PT = Patellar Tendon, MJLA = Medial Joint Line Area, SM = Superior Medial, LJLA = Lateral Joint Line Area, SL = Superior Lateral, T = Tibia. Note that the posterior knee zone is not depicted in (A) as a tick box enabled participants to report pain in the posterior knee (as present or absent). The proportion of the cohort (n = 164) reporting pain in each of the regions is indicated in (B).

'severe physical dysfunction' (score 4)) and giving a maximum score of 68. Moderate to excellent test–retest reliability and internal consistency have been reported in OA[23].

Average knee pain intensity, as well as pain on walking, were quantified over the past week using 11-item NRSs ('no pain' (score 0) and 'worst pain possible' (score 10)). These scales have excellent test–retest reliability and construct validity in people with arthritic or other chronic pain conditions[24,25].

The Intermittent and Constant Osteoarthritis Pain (ICOAP) questionnaire is an 11-item tool designed to assess pain in hip or

knee OA taking into account both constant and intermittent pain experiences. All items are constructed as five-point Likert response scales. For questions asking about intensity, terminal response options are 'not at all' (score 0) and 'extremely' (score 4), while those about frequency have terminal response options of 'never' (score 0) to 'very often' (score 4). To calculate constant and intermittent pain subscale scores, scores for items one through five are summed giving a maximum score of 20 whereas scores for items 6 through 11 are summed giving a maximum score of 24, respectively. Intermittent and constant pain scores were transformed and summed to obtain total scores ranging 0 (no pain) to 100 (maximum pain), which were used for analysis. ICOAP showed excellent reliability, internal consistency and construct validity in OA[25,26].

Although not validated as an indicator of neuropathy in OA, the painDETECT questionnaire classifies pain as unlikely, unclear/possible or likely to have a neuropathic-like component (www.pfizerpatientreportedoutcomes.com). The tool includes three questions about knee pain intensity rated via NRSs ('no pain' (score 0) to 'worst pain possible' (score 10)), pain course pattern rated via a diagram displaying four possible pain course patterns (scored −1 to 2 depending on which pain course pattern is selected), a question about pain radiation (answered yes/no, and scored 2 or 0 respectively), and seven questions about somatosensory phenomena each rated on 6-point Likert scales ('never' (score 0) to 'very strongly' (score 5)). Total scores are obtained by summing scores for all items, ranging from 0 to 38. Higher scores indicate more neuropathic-like symptoms. Scores of ≤12 indicate pain is unlikely to be neuropathic and scores of ≥19 suggest pain is likely to have a neuropathic component. Scores ≥13 and ≤18 indicate uncertain results and the possibility of a neuropathic component[27]. We categorised participants accordingly and also used mean scores for analyses. painDETECT has excellent test–retest reliability and good internal consistency in symptomatic knee OA[4,28].

Presence of current symptoms (pain, aching, discomfort or stiffness) at other joints (each of hand, neck, back, hip, foot/ankle, shoulder) was evaluated by a simple yes/no categorization at each site. We also calculated the total number of distant sites with current symptoms for each participant.

Statistical analysis

Statistical analyses were performed using SPSS (version 22, IBM Statistics, Armonk, New York, USA). Level of significance was set at $\alpha < 0.05$. Descriptive statistics were calculated and continuous variables reported as means (standard deviations, SD). Categorical data are presented as *n* (%) and 95% confidence intervals (95% CI)[29]. Standard diagnostic residual plots were used to check normality assumptions.

To address our first aim in describing the locations of pain, we undertook the following descriptive analyses, given that pain locations can be described in any number of ways:

i) Pain zones – Proportions of participants reporting pain in each of the 10 zones [Fig. 2(A)] on the PKPM.
ii) Pain regions – Pain zone data was collapsed into pain regions [Fig. 2(B)][9]: 'Anterior' (pain reported in (any of) lateral and medial patella, quadriceps tendon or patella tendon zones), 'Medial' (pain in (any of) superior medial and medial joint line area zones), 'Lateral' (pain in (any of) superior lateral and lateral joint line area zones), 'Posterior' (pain in posterior knee zone) or 'Tibia' (pain in tibial zone).
iii) Pain patterns – Given that participants could theoretically experience pain in any combination of pain regions, we classified an individual's pattern according to the location of each individual's pain regions[9]. For example an individual with pain in both anterior and medial regions was classified as an 'anterior-medial' pattern, whilst a person with only medial region pain was classed as an 'isolated medial' pattern. In cases where more than two regions were affected by pain (e.g., a person with anterior, lateral and posterior pain regions), the participant was classified as having a 'diffuse pain' pattern[2,9].

Thus, "pain zones" were collapsed into "pain regions" to facilitate categorization of participants under single, and mutually exclusive, "pain patterns"[9], presented as proportions relative to the total sample. Thus, proportions also provide a measure of sensitivity of the pain zones/patterns for detecting radiographic medial TFJOA, according to the following formula and example:

$$\text{Sensitivity} = [\text{True Positives}/(\text{True Positives} + \text{False Negatives})]$$

$$\text{Example} = [\text{People with radiographic medial TFJOA and pain in the medial joint line zone}/(\text{People with radiographic medial TFJOA and pain in the medial joint line zone} + \text{People with radiographic medial TFJOA and no pain in the medial joint line zone})]$$

To address our second aim, we compared the differences in clinical symptoms across most common pain patterns. A one-way Analysis of Covariance (ANCOVA) was performed to investigate differences in continuous clinical variables across groups, with age, gender, BMI and history of knee surgery included as covariates given these variables have previously been associated with pain patterns in knee OA[3,9]. Subsequently, Least Significant Difference (LSD) post-hoc tests were used to further investigate significant main between-group effects. Given relatively low frequency counts of participants with likely neuropathic-like pain based on painDETECT scores, we categorised all participants with scores ≥13 as having possible/likely neuropathic-like symptoms. We compared proportions of those with unlikely neuropathic-like symptoms to those with possible/likely neuropathic-like symptoms across the most common patterns using a Chi-squared test. Chi-squared tests also compared prevalence of symptoms at other sites across common pain patterns.

Results

Participant characteristics are presented in Table I. Approximately half the sample was female, and on average the cohort was overweight. A spread of radiographic tibiofemoral disease severity was evident across participants based on KL grading, with grades 2, 3 and 4 similarly represented.

The proportion of the cohort reporting pain in each of the 10 knee zones on the PKPM is described in Table II, and summarized according to region in Fig. 2(B). Pain was most frequently reported at the medial joint line (75% of participants), followed by the patellar tendon (38%) and posterior zones (37%). The least frequently affected zone was the quadriceps tendon (5%). Most people reported pain in more than one zone, with predominantly two or three zones of pain identified by 35% (95% CI 28–43%) and 32% (95% CI 24–39%) of participants respectively. A single zone of pain was reported by 23% (95% CI 16–30%) of people, and 8% (95% CI 4–13%) and 2% (95% CI 0–4%) reported pain in 4 and 5 zones, respectively. Thus, the most sensitive pain zone for detecting radiographic medial TFJOA was the medial joint line, with a sensitivity of 75%.

Table I
Characteristics of study participants presented as mean (SD) unless otherwise stated

Characteristic	$n = 164$
Age (years)	64.3 (7.4)
Females (n, %)	84 (51)
BMI (kg/m^2)	29.7 (3.6)
Duration of symptoms (years)	9.2 (7.9)
History of previous knee surgery (n, %)	70 (43)
Radiographic disease severity	
KL grade (n, %)*:	
- Grade 2 (mild)	49 (30)
- Grade 3 (moderate)	52 (32)
- Grade 4 (severe)	63 (38)
Medial tibiofemoral JSN (n, %)†:	
- Grade 0 (normal)	0 (0)
- Grade 1 (mild)	47 (29)
- Grade 2 (moderate)	50 (30)
- Grade 3 (severe)	67 (41)
Medial femoral osteophytes (n, %)†:	
- Grade 0 (normal)	30 (18)
- Grade 1 (mild)	44 (27)
- Grade 2 (moderate)	57 (35)
- Grade 3 (severe)	33 (20)
Medial tibial osteophytes (n, %)†:	
- Grade 0 (normal)	4 (2)
- Grade 1 (mild)	70 (43)
- Grade 2 (moderate)	63 (38)
- Grade 3 (severe)	27 (17)
Lateral tibiofemoral JSN (n, %)†:	
- Grade 0 (normal)	149 (91)
- Grade 1 (mild)	12 (7)
- Grade 2 (moderate)	3 (2)
- Grade 3 (severe)	0 (0)
Lateral femoral osteophytes (n, %)†:	
- Grade 0 (normal)	95 (58)
- Grade 1 (mild)	50 (31)
- Grade 2 (moderate)	15 (9)
- Grade 3 (severe)	4 (2)
Lateral tibial osteophytes (n, %)†:	
- Grade 0 (normal)	42 (26)
- Grade 1 (mild)	92 (56)
- Grade 2 (moderate)	25 (15)
- Grade 3 (severe)	5 (3)
Clinical symptoms	
WOMAC:	
- Pain subscale (score range 0–20)	8.5 (2.8)
- Physical function subscale (score range 0–68)	28.7 (10.1)
NRS pain on walking (score range 0–10)	5.8 (1.7)
NRS average pain (score range 0–10)	5.8 (1.5)
ICOAP:	
Total Score (score range 0–100)	37.3 (15.3)
Constant pain subscale (score range 0–100)	31.3 (19.3)
Intermittent pain subscale (score range 0–100)	42.4 (14.4)
painDETECT:	
Total score (score range 0–38)	8.4 (5.4)
- Unlikely neuropathic-like pain (scores 0–12), n (%)	132 (81)
- Possible neuropathic-like pain (scores 13–18), n (%)	23 (14)
- Likely neuropathic-like pain (scores 19–38), n (%)	9 (6)
Symptoms at other joint sites (n, %):	
- Hand	74 (45)
- Neck	70 (43)
- Back	74 (45)
- Hip	42 (26)
- Shoulder	65 (40)
- Ankle/Foot	68 (42)
Number of other joint sites with symptoms:	2.4 (1.7)

WOMAC: the higher the score the worse the pain/physical dysfunction. ICOAP questionnaire: the higher the score the worse the total or intermittent/constant pain and the more related distress.

* = Using the Kellgren and Lawrence (KL) grading system where grade 2 = definite osteophytes and possible JSN, grade 3 = moderate multiple osteophytes, definite JSN and possible bone deformity and grade 4 = large osteophytes, marked JSN, severe sclerosis and definite bone deformity[20].

† = Using a standard radiographic atlas where grade 0 = normal, grade 1 = mild, grade 2 = moderate and grade 3 = severe[21].

Table II
Frequency of pain in each of the 10 knee zones, based on the PKPM. Presented in the order of most frequent to least frequent pain zones

Zones	Frequency n (%, 95% CI)
Medial aoint line area	123 (75, 68–82)
Patellar tendon	62 (38, 31–45)
Posterior	61 (37, 30–45)
Superior medial	56 (34, 27–42)
Lateral joint line area	43 (26, 20–33)
Medial patella	43 (26, 20–33)
Tibia	36 (22, 16–28)
Lateral patella	30 (18, 13–24)
Superior lateral	14 (9, 4–13)
Quadriceps tendon	9 (5, 2–9)

95% CI = 95% Confidence Interval (lower bound-upper bound). Sum of zone counts exceeds the total number of participants in this sample ($n = 164$) because participants could report pain in more than one zone.

Pain patterns are described in Table III, with a wide variety of patterns observed. Most common patterns were diffuse pain (41% of the cohort), followed by isolated medial pain (16%), anterior-medial pain (12%) and medial-posterior pain (11%). Sensitivity of the isolated medial pain pattern for detecting people with radiographic medial TFJOA was thus quite low at only 16%.

Clinical symptoms for the sample are described in Table I. Table IV summarizes clinical symptoms across the most common pain patterns ($n = 133$). Participants with diffuse pain reported significantly worse WOMAC pain (mean difference 1.5 units (95% CI 0.1–2.9), $P = 0.032$) and function scores (mean difference 5.3 units (95% CI 0.3–10.3), $P = 0.037$) compared to those with anterior-medial pain. Similarly, ICOAP total score (mean difference 9.7 units (95% CI 2.2–17.3), $P = 0.012$) was significantly higher with a diffuse pattern compared to anterior-medial patterns. Mean painDETECT scores were higher in both the diffuse pain (mean difference 3.7 units (95% CI 1.1–6.4), $P = 0.007$) and posterior-medial patterns (mean difference 4.2 units (95% CI 0.8–7.6), $P = 0.017$) relative to anterior-medial patterns. This was reflected in a tendency for a higher proportion of people with possible/likely neuropathic-like pain in the diffuse ($n = 18$, 26%) and posterior-medial group ($n = 4$, 22%) when compared to the anterior-medial group ($n = 1$, 5%) ($P = 0.25$). Whilst the mean number of distant sites with symptoms did not significantly differ across pain patterns ($P = 0.65$), a significantly greater proportion of participants with diffuse patterns ($n = 40$, 59%) reported concomitant back symptoms compared to isolated medial patterns ($n = 7$, 26%) ($P = 0.032$).

Table III
Frequency of pain patterns, presented in order of most frequent to least frequent pain patterns

Patterns	Frequency n (%, 95% CI)
Diffuse pain	68 (41, 34–49)
Isolated medial	27 (16, 11–23)
Anterior-medial	20 (12, 8–17)
Medial-posterior	18 (11, 7–16)
Medial-tibial	8 (5, 2–9)
Isolated anterior	7 (4, 2–7)
Anterior-tibial	5 (3, 1–6)
Isolated lateral	3 (2, 0–4)
Medial-lateral	3 (2, 0–4)
Anterior-posterior	2 (1, 0–3)
Anterior-lateral	1 (1, 0–2)
Lateral-posterior	1 (1, 0–2)
Isolated tibia	1 (1, 0–2)

95% CI = 95% Confidence Interval (lower bound-upper bound). The sum of knee pain patterns equals the sample size of $n = 164$ since, according to this classification system, all individuals were categorized under one single pattern of knee pain. Percentages are rounded off.

Table IV
Comparison of clinical symptoms across the most common anatomical patterns of pain, reported as mean (SD) unless otherwise stated

	Anatomical pain patterns				
	Diffuse ($n = 68$)	Isolated medial ($n = 27$)	Anterior-medial ($n = 20$)	Medial-posterior ($n = 18$)	*P*-value*
NRS pain on walking (score range 0–10)	6.1 (1.9)	5.5 (1.7)	5.7 (1.6)	6.2 (1.4)	0.15
NRS average pain (score range 0–10)	6.0 (1.6)	5.6 (1.5)	5.8 (1.2)	5.6 (1.1)	0.56
WOMAC pain (score range 0–20)	9.3 (2.8)‡	8.2 (2.6)	7.8 (2.4)	8.5 (3.1)	0.037
WOMAC physical function (score range 0–68)	30.9 (9.6)‡	27.9 (11.2)	25.6 (7.4)	29.9 (12.5)	0.048
ICOAP total score (score range 0–100)	41.2 (14.5)‡	38.6 (16.5)	31.1 (11.8)	36.6 (19.3)	0.023
painDETECT total score (score range 0–38)	9.3 (5.7)‡	7.3 (4.9)	5.5 (4.4)	9.5 (5.1)‡	0.048
- Possible/likely neuropathic-like pain (scores 13–38)†	18 (26%, 16–37)	4 (15%, 4–30)	1 (5%, 0–15)	4 (22%, 6–39)	0.25
Symptoms at other joint sites:†					
- Hand	31 (46%, 34–57)	14 (52%, 33–70)	6 (30%, 10–50)	8 (44%, 22–67)	0.65
- Neck	34 (50%, 38–62)	5 (19%, 4–33)	10 (50%, 25–70)	7 (39%, 17–61)	0.07
- Back	40 (59%, 47–71)§	7 (26%, 11–44)	8 (40%, 20–60)	6 (33%, 11–56)	0.03
- Hip	20 (29%, 19–41)	7 (26%, 11–41)	3 (15%, 0–35)	4 (22%, 6–44)	0.77
- Shoulder	25 (37%, 25–49)	11 (41%, 22–59)	9 (45%, 25–65)	7 (39%, 17–61)	0.97
- Ankle/Foot	30 (44%, 32–56)	7 (26%, 11–44)	8 (40%, 20–60)	7 (39%, 17–61)	0.37
Number of other joint sites with symptoms:	2.6 (1.7)	1.9 (1.7)	2.2 (1.4)	2.2 (1.6)	0.65

* *P*-values for one-way ANCOVA main effects controlled for age, gender, BMI and history of previous knee surgery (continuous variables), or *P*-values for 4 × 2 Chi-square (categorical variables), non-significant *P*-values are rounded off.
† = Reported as *n* (%, 95% CI); ICOAP: higher scores indicate worse pain intensity and related distress for either intermittent or constant pain; WOMAC: higher scores indicate worse pain or physical function scores in pattern.
‡ $P < 0.05$ when compared to the anterior-medial pain pattern.
§ $P < 0.05$ when compared to the isolated medial pain pattern.

Discussion

The goal of this study was to describe location of knee pain in definite medial TFJOA using the patient-administered PKPM, and to examine differences in clinical symptoms across the most common pain patterns. Despite all participants having radiographic medial TFJOA, we found only 16% of people reported isolated medial knee pain, and 15% did not experience any medial pain (in either the medial joint line or superior medial knee zones) at all. A wide variety of patterns were observed, with the most common being diffuse pain. Some patterns were associated with clinical symptoms. Specifically, people with diffuse pain reported worse pain and physical function compared to anterior-medial patterns, although only differences in function approach a clinically relevant threshold. While a greater proportion of people with diffuse pain suffered back symptoms, a tendency existed for more participants with both diffuse and posterior-medial pain to experience possible/likely neuropathic-like symptoms than those with anterior-medial patterns, although the clinical relevance of these findings is uncertain.

In the present study, zones most frequently affected by pain were the medial joint line, followed by the patellar tendon, posterior and superior medial knee. Consequently, the medial, anterior and posterior knee regions were most often identified as painful locations. Our finding that the medial and anterior knee were frequently affected by pain agrees with data derived from other mapping methods in knee OA[2,3,9,10]. However, previous research has suggested that the posterior knee is an infrequent pain location[2,9]. We found 37% of our cohort reporting posterior knee pain, compared to only 5–11% reported previously in people with or at risk of knee OA[2]. Although the posterior knee was included in diagrams utilized in elderly adults with frequent knee pain and with or without radiographic knee OA in previous studies[2,9], this region either was excluded *a priori* as a potential site of pain[9] or may have been under-reported as a result of patient positioning at the time of data collection[2]. Common interviewer-administered methods of knee pain mapping often require participants to sit on the edge of an examination table (knees flexed to 90°) and point to painful sites on their knee[2], which may limit participants ability to identify painful posterior knee zones. Plausible contributors to posterior knee pain in OA include a Baker's cyst secondary to degenerative joint changes, injuries or calcification in the popliteus tendon, gastrocnemius or hamstrings injuries, or referred pain from the lumbar spine[30].

In contrast to our findings, Thompson *et al.*[2] concluded that knee OA pain was characterized by a localized, rather than diffuse, pain pattern. These authors observed only 24% of participants with diffuse pain as opposed to half with local pain. This may be because Thompson *et al.*[2] analysed pain maps from a sample predominantly comprising people with milder disease on average (73% of the cohort with KL grades <2) when compared to our sample. Differences between studies may also be due to different mapping methods and definitions used. In the studies by Thompson and colleagues[2,3], participants who could not identify localized pain with one or two fingers, or regional pain with their hand covering the painful area, and/or those who said the pain was “all over” were classified as having diffuse pain. Our observations agree with Wood *et al.*[9] who, by using a 13-zone interviewer-administered knee diagram, described whole knee pain as the most common pattern in symptomatic radiographic knee OA, followed by an isolated medial and anterior-medial knee pain pattern.

Our results confirm that pain and physical dysfunction are more severe in diffuse pain compared to more localized patterns[3,9,10,31], however only differences in the WOMAC function scores approach the minimal clinically relevant difference[32]. Ours is the first study to relate knee pain patterns to painDETECT scores. Although not statistically significant, we found 26% of people with diffuse pain had pain with a possible/likely neuropathic-like component compared to 5% with anterior-medial patterns and 4% of isolated medial pain. While the majority of our cohort experienced nociceptive-like symptoms, our data suggest that neuropathic-like pain may be more frequent amongst those with diffuse pain. Interestingly, we also observed that 22% of people with medial-posterior patterns had pain with a possible/likely neuropathic-like component. We cannot draw conclusions, or make assumptions about, causes of pain from our present study. While the increased neuropathic-like symptoms associated with diffuse pain patterns may be due to peripheral neuropathy resulting from OA pathological processes, these findings may also indicate radiculopathy or other such neuropathic issue unrelated to knee OA. Our data, showing a high proportion of back pain in people with diffuse knee pain, supports the latter.

Our study has a number of limitations. We had a relatively small sample size. Given the wide variety of patterns observed, this resulted in small frequency counts for some patterns, which limited our analyses to the most frequently occurring patterns. We also confined the PKPM assessment to the most painful eligible knee, despite the high prevalence of bilateral disease in this population. We thus did not assess pain locations and patterns in the contralateral knee, which could quite feasibly influence clinical symptoms in this population. Although our participants were selected on the basis of definite radiographic medial TFJOA, many participants will have had concomitant lateral and/or patellofemoral OA, which probably explains the wide variety of pain locations reported in our cohort. As such one cannot generalize our findings to all persons with knee OA or knee pain. Finally, this was a cross-sectional study. We were not able to capture the fluctuating nature of pain locations in knee OA nor could we investigate the potential impact on changes in clinical symptoms over time.

Our study has implications for both clinical practice and future research. Clinicians should consider diffuse pain and posterior knee pain as common in medial TFJOA and should be aware that these pain patterns are associated with greater symptomatic burden on afflicted patients. Therefore, clinical assessment and treatment should not only focus on anterior-medial knee pain, the traditional targets for physical therapists treating people with knee pain, but should also contemplate possible sources of posterior knee pain. Although no gold standard test exists for diagnosing neuropathic pain in knee OA, assessment should also consider evaluation of neuropathic-like symptoms, which may sometimes go unrecognized in the typical clinical assessment of a patient with OA[4]. Future research should also aim to elucidate the underlying causes that drive pain patterns in people with knee OA.

Our data show that not all people with medial radiographic TFJOA experience pain in the medial knee regions, supporting previous studies that show knee pain location is not well correlated with radiographic OA[9]. This has implications for researchers, who should not necessarily rely on subjective reports of medially-located knee pain to identify research participants with medial TFJOA. Although pain in the medial joint line zone had a sensitivity of 75% for detecting people with radiographic medial TFJOA, a pattern of isolated medial knee pain yielded a sensitivity of only 16%. Hence, our data suggest that researchers would be best to select patients on pain at the medial joint line zone, irrespective of the presence of concurrent pain in other zones, rather than on the basis of pain isolated to the medial knee region. We did not include a cohort without radiographic TFJOA, therefore we could not determine the specificity of knee pain locations for diagnostic purposes and future research in this area is thus warranted.

Conclusion

In medial TFJOA, a range of pain patterns can be expected. However, diffuse knee pain is most common and associated with more severe knee pain and physical dysfunction than anterior-medial patterns. Although neuropathic-like symptoms were relatively uncommon in our cohort, people with diffuse or posterior-medial pain tended to experience more neuropathic-like symptoms. Future research should aim to further understand the underlying causes of pain locations in knee OA.

Author contributions

AVG: analysis and interpretation of the data, drafting the article, critical revision of the article for important intellectual content, final approval of the article; KLB: conception and design, analysis and interpretation of the data, critical revision of the article for important intellectual content, final approval of the article; TW: conception and design, analysis and interpretation of the data, critical revision of the article for important intellectual content, final approval of the article; DH: conception and design, analysis and interpretation of the data, critical revision of the article for important intellectual content, final approval of the article; PC: critical revision of the article for important intellectual content, final approval of the article, provision of study materials or patients, collection and assembly of data; RH: conception and design, analysis and interpretation of the data, drafting the article, critical revision of the article for important intellectual content, final approval of the article, obtaining of funding.

Conflicts of interest

Dr. Hinman reports personal fees and other from Asics, Oceania, personal fees for the Osteoarthritis DVD, other from Australian Research Council, Future Fellowship #FT 130100175, personal fees from Editorial Board member for Physical Therapy journal, outside the submitted work; Dr. Bennell reports personal consultancy fees from Physitrack, pending grants with the National Health & Medical Research Council and Australian Research Council, personal fees from Asics Oceania, personal fees for the Osteoarthritis DVD, outside the submitted work; Mr Wrigley reports pending grants from the National Health & Medical Research Council and personal fees from Asics Oceania; No other conflicts of interest were reported.

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