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The Knee Pain Map: Reliability of a Method to Identify Knee Pain Location and Pattern

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Abstract

Objective—To describe the location and pattern of knee pain in patients with chronic, frequent knee pain using the Knee Pain Map, and to evaluate the inter- and intrarater reliability of the map.

Methods—A cohort of 799 participants from the University of Pittsburgh Osteoarthritis Initiative Clinical Center who had knee pain in the last 12 months were studied. Trained interviewers assessed and recorded participant-reported knee pain patterns into 8 local areas, 4 regional areas, or as diffuse. Inter- and intrarater reliability were assessed using Fleiss' kappa.

Results—Participants most often reported localized (69%) followed by regional (14%) or diffuse (10%) knee pain. In those with localized pain, the most commonly reported locations were the medial (56%) and lateral (43%) joint lines. In those with regional pain, the most commonly reported regions were the patella (44%) and medial region (38%). There was excellent interrater reliability for the identification of localized and regional pain patterns ($\kappa = 0.7$ – 0.9 and 0.7 – 0.8 , respectively). The interrater reliability for specific locations was also excellent ($\kappa = 0.7$ – 1.0) when the number of participants with pain in a location was >4 . For regional pain, the kappa for specific regions varied from 0.7 – 1.0 .

Conclusion—The majority of participants could identify the location of their knee pain, and trained interviewers could reliably record those locations. The variation in locations suggests that there are multiple sources of pain in knee OA. Additional studies are needed to determine whether specific knee pain patterns correlate with discrete pathologic findings on radiographs or magnetic resonance images.

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AUTHOR CONTRIBUTIONS

All authors were involved in drafting the article or revising it critically for important intellectual content, and all authors approved the final version to be submitted for publication. Dr. Kwoh had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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INTRODUCTION

Osteoarthritis (OA) is the most prevalent form of arthritis and is among the most prevalent chronic conditions in the US (1). Data from the population-based Framingham Osteoarthritis Study indicate that 33% of people age >65 years had radiographic evidence of knee OA, and 9.5% reported symptomatic knee OA (2). Although knee pain is the most common presenting symptom of knee OA, the etiology of knee pain in knee OA is not well understood. In addition, the localization and patterns of pain location felt by patients with knee OA are not well defined. There has been limited information on knee pain patterns and locations due to the lack of a reliable instrument to assess these features in patients with knee OA.

To our knowledge, 3 studies focusing on knee pain location have asked subjects with knee pain to identify the location of their pain. The first such study, by Creamer et al, asked patients with knee OA to specify locations of current pain by shading the painful areas on a drawing of the knee. The drawing was then divided into 4 quadrants for data collection. All participants were able to localize their pain, and the most common patterns were inferior-medial quadrant pain and generalized pain (3). Sengupta et al identified pain as medial tibiofemoral, lateral tibiofemoral, or patellar, and compared the location of pain with magnetic resonance imaging (MRI) signal density in knee osteophytes. They found that the patella was the most common location of pain (4). More recently, Wood et al asked subjects with knee pain to indicate “where your knee hurts,” and interviewers recorded the locations by shading areas on a blank knee mannequin (5). Specific locations were categorized by overlaying a transparent template divided into 13 areas. They then identified the most frequently reported areas of pain and the most common patterns of pain (i.e., areas of pain that occurred together), which were generalized, medial and lateral, medial and patellar, isolated medial, and peripatellar. Additionally, they suggested that radiation of pain down the lower leg is more common in patients with knee OA. However, the lack of data on reproducibility for their method limits its utility for other studies. For example, it is not known how reliably subjects’ pain location reports were transferred to the mannequin. None of these studies have included methods to assess both where patients have pain and the pattern of pain involvement relative to specific anatomic landmarks such as the patella or medial or lateral joint lines.

To address the need for a simple, reliable method of identifying and recording knee pain locations and patterns, we developed and examined the intra- and interrater reliability of the Knee Pain Map, an interviewer-administered assessment of knee pain patterns and locations. The Knee Pain Map allows patients to identify the location of pain and also allows interviewers to classify the pattern of participants’ pain as local, regional, or diffuse.

SUBJECTS AND METHODS

Participants

The Osteoarthritis Initiative (OAI) is a longitudinal cohort study of persons with knee OA or with increased risk for developing knee OA, with the goal of identifying biomarkers for the development and/or progression of the disease. A total of 4,796 men and women between the ages of 45 and 79 years were enrolled through a community-based recruitment at 4 clinical centers: the University of Pittsburgh, Pittsburgh, Pennsylvania; Ohio State University, Columbus, Ohio; Memorial Hospital, Pawtucket, Rhode Island; and the University of Maryland/Johns Hopkins University, Baltimore, Maryland. At baseline, just under one-third of the participants had symptomatic, radiographic tibiofemoral OA in ≥ 1 knee, defined as both radiographic evidence of knee OA (Osteoarthritis Research Society International atlas osteophyte grades 1–3 [6]) and, in the same knee, pain, aching, or stiffness on most days of 1 month in the past 12 months. The remaining participants had risk factors for knee OA (knee pain without radiographic knee OA, obesity, a history of knee surgery or knee injury, family

history of knee replacement, or hand OA) or were part of a small control group. Participants had annual clinic visits for the OAI that included interviews, knee examinations, knee radiographs, knee MRIs, and biologic specimen collection. Data and joint images collected in the OAI are available from public use data sets (online at www.oai.ucsf.edu).

Knee Pain Maps were obtained in a sample of 860 OAI participants at the University of Pittsburgh Clinical Center as part of their regularly scheduled baseline or 12-month followup visit between June 2005 and July 2006. Participants were included in the study if they had pain, aching, or stiffness in the last 12 months in ≥ 1 knee. Participants were excluded if they had previously had a knee replacement. No patients refused to participate in this study. This report includes information from 799 participants whose other baseline and 12-month followup clinical data were available from the public data release (data release 3.0.0 for enrollee data, 0.2.1 for baseline data, 1.1.1 for 12-month medical history, and 1.1.2 for other characteristics). The study was approved by the University of Pittsburgh Institutional Review Board and the OAI Ancillary Studies Committee.

The Knee Pain Map is an interviewer-administered assessment that identifies areas of the knee that are painful and characterizes knee pain as localized (patellar, superior-medial, inferior-medial, medial joint line, superior-lateral, inferior-lateral, lateral joint line, or back of knee), regional (medial, lateral, patellar, or back of the knee), or diffuse/unable to identify pain as localized or regional in nature. This classification was based on empirical data from clinical experience of how patients describe where their knee hurts, and by using specific anatomic landmarks such as the patella and joint line. Pilot studies were performed, using earlier versions of the Knee Pain Map, during which we defined >20 possible areas of knee pain. Because pain was very infrequently reported in some areas and because reproducibility was poor due to the number of areas, we reduced the number of areas to the current 8 local areas and 4 regional areas. The Knee Pain Map diagram consists of an artist's drawing of the participant's knees from the point of view of the examiner while the participant is sitting on the edge of an examination table with the knees flexed to 90 degrees (Figure 1). Each of the localized and regional areas of pain are depicted on the knee diagram, which is used by the interviewer to record the participant's response.

Trained interviewers administered the Knee Pain Map while participants sat in the same position as illustrated in Figure 1. This allowed the participant to be able to easily and safely see and point to areas where they felt pain. The interviewers were trained to identify, classify, and record the various locations of pain using the diagram described above.

Localized pain was defined by the use of 1 or 2 fingers to point to a specific location, whereas regional pain was defined by the use of all of the fingers or the whole hand to cover a more extensive region. Participants were first asked to use 1 or 2 fingers to point to specific areas where they had pain in the past 12 months. If a participant could not localize his or her pain using 1 or 2 fingers, they were asked to use a hand or palm to cover the region of pain. Participants who were not able to identify areas of localized or regional pain and/or who said that the pain was "all over" the knee were classified as having diffuse pain or unable to define pain as localized or regional. If a participant stated that they had pain in the last 12 months but that they could not remember the location of pain, this was recorded as "unable to remember." Participants were excluded if during this examination they identified stiffness only with no pain or aching. Participants were allowed to identify multiple areas of localized and/or regional pain, if applicable. Participants could also identify 1 location and 1 non-overlapping region of pain.

For the purposes of analysis, some patterns of pain that included several locations or regions of pain were classified as diffuse pain. This was based on the assumption that if a participant

pointed to or covered many areas of pain, they were actually covering the majority of their knee, and the pain was indeed “all over.” The following were classified as diffuse pain: >3 areas of localized pain, >2 regions of pain, and >1 location and 1 non-overlapping region.

Reliability

Interrater reliability was assessed in 24 participants by 2 observers, the participants' primary OAI examiner and a second examiner from the OAI staff. A total of 7 interviewers participated in the interrater reliability study. The interviewers independently recorded the areas of knee pain reported by a single participant during the same examination session.

Intrarater reliability was assessed in 88 participants by having the same observer administer the Knee Pain Map in 2 separate sessions separated by 1–3 hours. This time period was chosen based on the duration of the OAI clinical visits.

Statistical analysis

In the cases where >1 interviewer evaluated the participant for the interrater reliability study, the pattern of knee pain collected by the participant's primary OAI examiner was used for the analysis of frequency of knee pain locations. In the cases for which the Knee Pain Map was administered twice by the same interviewer for the intrarater reliability study, the first administration of the Knee Pain Map was used for the frequency analysis.

Descriptive statistics used to describe the frequency of knee pain locations and patterns were calculated using Stata software, version 10 (Stata, College Station, TX). Fleiss' kappa (7), a kappa statistic that corrects for assessments by multiple interviewers to determine reliability, was also calculated using Stata. Inter- and intrarater reliability were calculated using Fleiss' kappa. For the inter-rater reliability, each participant was rated by 2 of 7 different raters, and the kappa calculation was structured to account for nonunique raters. Kappas were calculated using pain as present versus absent in each relevant area.

RESULTS

Study population

A total of 799 participants with complete data sets were included in this study. The age range was 49–75 years (mean 62.7 years), and 55% were women. Sixteen percent of the participants were African American, and 1% were other nonwhites. The mean body mass index for participants was 28.1 kg/m² (range 6.8–44.0 kg/m²). Twenty-seven percent of participants met the OAI definition for symptomatic knee OA at their baseline visit, and the remainder had risk factors for knee OA but did not meet the criteria for both symptomatic and radiographic OA in the same knee at their baseline visit.

Knee pain patterns

Pain in the last 12 months was reported in the right knee by 622 participants and in the left knee by 592 participants. Bilateral knee pain was reported by 492 participants. Of all knees with pain, 86% had local or regional pain. Participants most often reported knees with localized pain (69% and 66% for the right and left knees, respectively) followed by regional and then diffuse pain (10% and 11%, respectively) (Table 1). Of knees with localized pain, 54% had pain in only 1 location, 30% had pain in 2 locations, and 15% had pain in 3 locations. Of knees with regional pain, 81% of knees had pain in only 1 region, and 19% of knees had pain in 2 regions. Two percent of knees had 1 location and 1 region for each knee. Approximately half of the knees that were classified as having diffuse pain or pain unable to be described as localized or regional were originally described by participants as having pain in either >3 locations, >2 regions, or >2 non-overlapping locations and regions.

In participants with localized knee pain, the most commonly reported locations were the medial joint line (54% and 58% for the right and left knees, respectively), lateral joint line (44% and 41%, respectively), and patella (36% and 31%, respectively). Pain was less commonly reported in the inferior lateral area, the back of the knee, the superior lateral area, and the superior medial area (Table 2). In participants with regional knee pain, the most commonly reported regions were the patella (43% and 45% for the right and left knees, respectively) and the medial region (42% and 35%, respectively), whereas the lateral region (25% and 26%, respectively) and the back of the knee (14% and 11%, respectively) were less commonly reported.

The most common patterns of pain were the medial joint line only (12.7% and 16.6% for the right and left knees, respectively), the local patella area only (14.4% and 8.8%, respectively), and the medial and lateral joint line together (11.9% and 10.6%, respectively) (Table 3).

Interrater reliability

There was excellent interrater reliability for identification of localized and regional pain patterns (Table 4). The interrater reliability for specific locations was also excellent ($\kappa = 0.7$ – 1.0) when the number of participants with pain in that area (n) was >4 (Table 5). When n was ≤ 4 , the kappa values for the individual locations ranged from 0.3–0.8. Specific localized kappa values were highest in the most common locations of pain, the medial and lateral joint lines ($\kappa = 0.7$ – 1.0).

There was also excellent test–retest reliability (Tables 4 and 5). For localized and regional pain patterns, $\kappa = 0.87$ and 0.68 for the right knee, respectively, and $\kappa = 0.80$ and 0.76 for the left knee, respectively. The specific locations ranged from $\kappa = 0.7$ – 1.0 when n was >4 and from $\kappa = 0.6$ – 1.0 when n was ≤ 4 . For regional pain, specific regions varied from $\kappa = 0.4$ – 1.0 when n was >4 .

DISCUSSION

In this study, we found that most patients with knee pain could identify pain locations and patterns and that trained examiners could reliably record the location of knee pain using the Knee Pain Map. To our knowledge, this is the first study that allowed patients to either point to an area or cover a region where it hurts, giving the patient the responsibility of identifying their pain as being in a specific location versus a more general region. Prior studies have generally had patients point to multiple areas, and then the investigator defined patterns and regions of pain in post hoc analysis of the various areas that the patient pointed to. We found the most common locations of pain to be the medial joint line, the lateral joint line, and the patella. The most common regions of pain were the patella region and the medial region. We have shown that the Knee Pain Map is a reliable instrument in a community-based cohort of participants with knee OA or with risk factors for the development of knee OA.

These results support the premise that pain from knee OA is likely due to several different pathologic features. Given the diverse locations of pain, it is likely that there are several different sources of pain. Nerve endings are absent in the cartilage itself; however, the subchondral bone, periosteum, synovium, and ligaments contain nerve endings that may be sources of painful sensation. The severity and location of pain may be the result of both local and central factors, including the severity of OA in the knee and more central sensitization to painful stimuli (8). Synovial thickening apparent on MRI has been associated with knee pain in OA (9). Bone marrow lesions have also been associated with knee pain, particularly in the case of larger lesions (10,11). The most common locations of pain, that is, the medial and lateral joint line and the patella, are not surprising given these possible sources of pain.

It is of interest that localized pain was the most frequently reported pattern of pain. It may be that different patterns of pain correlate to specific MRI and radiograph findings. In clinical practice, clinicians have noted that patients report differences in pain patterns. Prior studies have not focused on the hierarchical nature of pain patterns as local, regional, or diffuse, and the Knee Pain Map begins to address this issue.

In designing the Knee Pain Map, we used several iterations of knee diagrams beginning with a simple line and circle computer-drawn diagram similar to that of Creamer et al, but found that interviewers were more able to identify specific locations using an artistic rendition of the knee drawn from the perspective of the interviewer. The interviewers were trained to perform a standard clinical knee examination as part of the OAI and could identify anatomic landmarks that allowed them to use the diagram to identify specific locations of pain.

Although Creamer et al found that participants could localize knee pain, they did not use an anatomically relevant diagram to record knee pain. They found that generalized and medial pain were the most common patterns. Their finding of more frequent generalized pain may have been because the diagram only allowed for recording a few locations of pain and did not allow for the full range of pain that patients with knee pain often report. Their finding of frequent medial pain was consistent with our results.

Similarly, Sengupta et al focused only on commonly reported locations of pain. These locations were consistent with the locations and patterns that we found to be most common; however, because they allowed identification of only these common locations of pain, it is not clear whether they allowed the option of less commonly reported locations of pain.

Wood et al found that generalized knee pain was the most common, followed by combinations of medial, lateral, and peripatellar pain. Our finding (that the most common areas and patterns of pain among all participants were the medial joint line only, the lateral joint line only, and the combination of the medial and lateral joint line only) agrees with their results. Their specific location findings were relatively consistent with our study; however, we found diffuse pain to be much less common than they found (10% versus 33%). This difference may have been due to different study populations and thus differences in demographics and/or risk factors, but it may also have been due to the method of recording knee pain and the collapsing of locations into a few specific patterns by Wood et al. In contrast, we allowed the participants to use gestures commonly used in clinical practice to identify pain patterns as localized, regional, or diffuse rather than collapsing specific categories based on the reporting of frequencies of each location or region. The mannequin used by Wood et al was complicated and contained many areas, which raises concerns for reproducibility and ease of use.

It is also important that the perspective of the Knee Pain Map, with the knee flexed at 90 degrees, is based on a position of the knee that is familiar to participants and examiners/providers. This flexed position separates the anatomy of the joint line that facilitates identification by the participant and the interviewer. Thus, it is easier for the participant to point to an area of pain and for the examiner to easily identify anatomic landmarks to allow reproducible identification of the location of the pain. Furthermore, as many individuals with OA are obese, when seated they are more likely to be able to comfortably reach their knee to point to specific areas of pain as compared with a position with their leg extended in front of them. In a prior study by Post and Fulkerson, participants with knee pain were told to color in areas of pain on line drawings of the knee with areas similar to the Knee Pain Map (12). However, the translation by participants of knee pain to a line drawing and not being able to point directly to their own knee likely reduced the accuracy and reproducibility of this method.

In our study, some patients reported pain in 2 or 3 locations or 2 regions. We also had several participants who had >3 areas of local pain or >2 regions of pain. During the analysis phase,

we made the decision to classify these participants as having diffuse pain or pain that was unable to be identified as localized or regional because it seemed that these participants were not able to localize their pain to 1 or more specific areas. However, despite this small group that was classified as having diffuse pain rather than having multiple areas of local or regional pain, we still found that only 10% of participants had diffuse pain.

There are several potential limitations to this study. First, it was a cross-sectional design at a single site. Therefore, our results may not be able to be generalized to other settings. Second, we used a broad screening question of “Have you had any knee pain or aching in the last 12 months?” and many of those responding yes may have had relatively mild or infrequent pain. Nevertheless, we found that the Knee Pain Map is reliable despite the broad range of knee pain studied. In earlier renditions of the Knee Pain Map, we considered having a separate area for the patella tendon insertion to differentiate between pain over the anserine bursa and pain over the patella tendon insertion. Pilot testing revealed, however, that there were only a small number of participants who described localized pain in the inferior areas, which overlies the anserine bursa and patella tendon insertion. In other populations, this may prove to be a more common site of pain.

Due to staffing constraints, the number for the interrater reliability was relatively small. However, among the most frequently reported patterns of pain, the kappa for interrater reliability was very good to excellent ($\kappa = 0.7$ – 1.0 when $n > 5$). Future work could include a larger interrater reliability study in order to strengthen these results. Similarly, for the intrarater reliability study we had a relatively short time period between the 2 administrations of the Knee Pain Map (1–3 hours). This may have been a shorter-than-ideal time period because participants may have recalled their prior answers, but the time period between administrations was limited due to the duration of the OAI clinical visits. Additional studies should be performed to address reliability over a longer time period.

In summary, we have demonstrated that the majority of patients with knee OA can identify localized or regional areas of their knee pain. Of these patients, localized knee pain is more common than regional knee pain. We have shown that the Knee Pain Map is a reliable tool for evaluating and recording knee pain locations. From a clinical standpoint, if we are able to reliably describe the location and/or pattern of knee pain and can correlate it with specific radiographic or MRI findings, we may be able to determine whether specific treatments are more or less efficacious for a given pain pattern or location. From a research standpoint, the implications of this study are 2-fold. First, the ability to reliably characterize knee pain location in patients with knee OA may improve our understanding of the causes of knee pain and the relationship of knee pain and pathologic findings. Second, methods such as this may prove useful in evaluating the success of new treatments for knee OA pain in specific locations. Studies are in progress to examine the correlation between specific knee pain patterns and specific features on knee radiographs and MRIs.

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Figure 1.

The Knee Pain Map diagram consists of an artist's drawing of the participant's knees from the point of view of the examiner. The interviewer uses the Knee Pain Map diagram to record the participants' responses, and classifies pain as localized (patellar, superior-medial, inferior-medial, medial joint line, superior-lateral, inferior-lateral, lateral joint line, or back of knee), regional (medial, lateral, patellar, or back of the knee), or diffuse/unable to identify pain as localized or regional in nature.

Table 1Occurrence of patterns of knee pain^{*}

	Right knee (n = 622)	Left knee (n = 592)
Localized [†]	69	66
Regional [‡]	13	15
1 location and 1 region	1.5	1.6
Diffuse/cannot localize [§]	10	11
Stiffness only	6	6
Unable to remember	1	2

^{*} Values are the percentage.[†] Up to 3 locations could be identified.[‡] Up to 2 regions could be identified.[§] Includes >3 locations, >2 regions, and >1 location and 1 non-overlapping region.

Table 2

Occurrence of knee pain in specific locations among those with localized pain*

	Right knee (n = 430)	Left knee (n = 397)
Medial joint line	54	58
Lateral joint line	44	41
Patella, localized	36	31
Superior medial	8.4	7.6
Superior lateral	6.2	5.0
Inferior medial	5.9	6.5
Back of knee, local	5.0	5.5
Inferior lateral	4.3	4.0

* Values are the percentage. Participants were allowed to identify >1 area of local pain, therefore these percentages add up to >100%.

Table 3

Most common patterns of pain in the individual and combined locations and regions*

	Right knee (n = 622)	Left knee (n = 592)
Medial joint line only	12.7	16.6
Patella local only	14.4	8.8
Medial joint line and lateral joint line	11.9	10.6
Lateral joint line only	7.4	6.4
Medial joint line, lateral joint line, and patella local	6.8	5.7
Medial region	3.2	3.4
Patella region	3.7	4.4
Lateral region	1.3	1.5
Medial region and lateral region	1.9	1.2

* Values are the percentage.

Table 4

No. of knees with and kappa statistics for specific patterns of knee pain

	Interrater, right knees		Interrater, left knees		Test-retest, right knees		Test-retest, left knees	
	No. of knees	κ	No. of knees	κ	No. of knees	κ	No. of knees	κ
Localized	16	0.91	19	0.68	43	0.87	42	0.80
Regional	6	0.75	4	0.83	11	0.68	14	0.76
Diffuse/cannot localize	0	*	1	*	6	0.74	8	0.65
Stiffness only	0	*	1	*	0	*	0	*
Unable to remember location/pattern of pain	0	*	0	*	3	0.79	3	1.0

* Kappa was not calculated because <3 subjects reported pain in this location.

Table 5
No. of knees with and kappa statistics for localized and regional areas of knee pain

	Interrater, right knees		Interrater, left knees		Test-retest, right knees		Test-retest, left knees	
	No. of knees	κ	No. of knees	κ	No. of knees	κ	No. of knees	κ
Localized								
Superior medial	4	0.63	2	*	4	0.58	2	*
Medial joint line	9	0.72	12	0.92	21	0.84	23	0.88
Inferior medial	2	*	1	*	3	0.66	2	*
Patella, local	3	0.78	2	*	22	0.75	17	0.78
Superior lateral	2	*	4	0.33	3	0.58	4	0.58
Lateral joint line	8	1.0	6	0.75	18	0.77	21	0.86
Inferior lateral	0	*	3	0.45	2	*	4	0.74
Back of knee, local	1	*	0	*	2	*	7	0.67
Regional								
Medial region	3	0.78	2	*	6	0.56	5	0.77
Patella region	3	0.47	2	*	3	0.85	7	0.43
Lateral region	3	0.78	3	1.0	4	0.39	5	0.66
Back of knee, regional	2	*	1	*	1	*	3	0.85

* Kappa was not calculated because <3 subjects reported pain in this location.