The photographic knee pain map: Locating knee pain with an instrument developed for diagnostic, communication and research purposes

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Abstract

Pain maps are used to determine the location of pain. Knee pain maps have previously been described, but only one study has reported on reliability and none report validity. The present study describes the generation of a photographic knee pain map (PKPM) together with its validity and reliability. A photographic representation of a pair of knees was chosen by 26 patients (66.7%) from a group of 39. The selected photograph was modified and a template of anatomical zones was generated. The opinions of 25 independent subject matter experts were canvassed and validity ratios calculated for these zones, ranging from 0.28 to 0.84. Hypothetical comparisons were made between the PKPM and an alternative knee pain map, in a cross-sectional group of 26 patients (35 knees). Convergent patterns of validity were found where hypothesised. Reliability was determined using a different cohort of 44 patients (58 knees) who completed the PKPM before and after a sampling delay. Four of these patients were excluded with a short sampling delay. Calculated agreement of test–retest reproducibility was fair to good. All of the completed PKPM (151 knees) were then subject to further analysis where inter-rater reproducibility was good to very good. The PKPM is readily accessible to patients with low completion burden. It is both valid and reliable and we suggest it can be used in both clinical and research settings. Further studies are planned to explore its predictive ability as a diagnostic tool. The PKPM can be found at www.photographickneepainmap.com.

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1. Introduction

Pain is the principle symptom of a range of knee pathologies [1]. Knee pain is one of the commonest regional musculoskeletal pains [2] and is reported by 25% of people aged over 55 years [3]. Pain has different features such as location, character, severity, and timing [4]. These different features can be recorded with different instruments, such as visual analogue scales to gauge severity [5] and pain maps to determine location [6].

Identifying the precise location of knee pain is important because the diagnostic process uses clinical judgement based upon pain site [1,4,7]. It is not known whether the location of knee pain changes during the natural progression of a disease process. Furthermore, surgical interventions may alter the location of knee pain, but this has yet to be proven. Therefore a valid and reliable instrument for determining knee pain location has potential implications as a research tool.

To our knowledge, five studies have looked at participants with regional knee pain to identify its location using proxy knee representa-
to report reliability, but only on a subset of participants from the much larger sample. Inter-rater reproducibility was assessed in 24 participants between seven trained observers and reported with kappa values from 0.33 to 1.0. Test–retest reproducibility was presented for a further 88 participants with kappa values ranging from 0.39 to 0.86. However, recall bias may have influenced reliability because the sampling delay was short (1 to 3 h). The method is also dependent upon an observer interpretation of pain location as indicated by the patient. Therefore, it has observer burden and may have a degree of observer bias. Validity was not described.

A new photographic knee pain map (PKPM) has been designed as an alternative to previous maps in the literature [8–12]. The PKPM is designed to determine only knee pain location as an instrument for diagnostic, communication and research purposes. The aim of this study was to determine the validity and reliability of the PKPM. It was hypothesised that the PKPM would demonstrate sufficient validity and reliability to enable its use in both clinical and research settings.

2. Materials and methods

2.1. Study design

This study is a description of instrument design together with validity and reliability analyses. The PKPM is patient-reported, but it is not strictly an outcome measure in the usual sense of the term i.e. designed to measure different facets of an underlying construct and resulting in a scaled scoring system. Instead it is an instrument designed to record only one facet (location) of an underlying construct (knee pain). However, it is still amenable to validity testing and this was performed upon a cross-sectional sample. Reliability assessment was performed using a cohort sample. Approval for the study was obtained from the review board of the County Durham and Tees Ethical Approval Committee.

2.2. Generation of the photographic knee pain map

The authors discussed and considered four possible models representing a pair of knees (Fig. 1). To ensure that the selected map would be recognisable to potential respondents a sample of patient opinion was canvassed. Thirty nine patients referred to a specialist knee clinic were asked to select which of the four diagrams “most clearly represented a pair of knees”. The photograph (Fig. 1D.) was selected and then refined on the basis of suggestions from this patient group. The photograph was retaken with the model in slight flexion and internal rotation to show skin on both sides of central patellae. Fine black outlines were added to emphasize the margins of the leg and the shadow of the extensor apparatus. The left and right legs were labelled for clarity. Patients were instructed to use small crosses when marking pain location, to encourage precise marking instead of broad shading. They were instructed to use several crosses, if needed, to indicate pain in more than one location (Fig. 2).

Different templates have been published previously which categorise knee pain into localised zones [8–12]. The common locations of knee pain have been identified [10–12]. After consideration of these...
Photographic knee pain map

Please use small crosses to mark where you feel your knee pain on this diagram:
(You can use several crosses if needed)

If you feel pain in the **back** of your **right** knee, tick here

If you feel pain in the **back** of your **left** knee, tick here

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2.3. Independent opinion of template zones

The authors generated a template of zones by the rationale described previously. An unbiased and independent opinion was
needed to confirm the importance of each zone in the PKPM template. Therefore an independent panel of 25 subject matter experts who were based at a different hospital were canvassed for their opinions. The panel included 16 orthopaedic surgeons, six physiotherapists, two rheumatologists and one clinical biomechanist. Validity ratios were calculated according to the method described by Lawshe [13], where responses indicating ‘essential’ zones were accounted. Statistically, values greater than 0.37 signified adequate validity for a panel of this size [13].

### 2.4. Validity testing

Validity is often evaluated by comparing an item within a measure against an item within another measure, which is hypothesised to be similar [14]. There will always be limitations when any new instrument is introduced if there is no established gold standard for comparison. Often the process requires selection of a comparable instrument which is the best possible match. In this study the knee pain map described by Thompson et al. [12] was selected for comparison with the PKPM. Twenty six patients referred to a specialist knee clinic were sampled; immediate post surgical patients and arthroplasty follow up patients were excluded. Fifteen patients were male and 11 were female, they ranged in age from 17 to 77 (mean of 43). Diagnosis was established by clinical assessment and radiological investigation (plain radiographs and magnetic resonance imaging when indicated). The range of knee pathologies is shown in Table 1. Patients completed the PKPM which was stored separately to blind the result from subsequent observation. A clinical observer then enquired about pain location which patients indicated by pointing with either their fingers or hands to locations which were recorded upon Thompson et al.’s map [12]. Hypotheses regarding which zones of the two maps should be similar were generated and these convergent patterns were sought by calculating agreement between the two maps. Whilst measuring the same entity (knee pain location), these two maps do not have identical zone boundaries. In order to compare like with like, the Boolean logic function, OR, was used during analysis to pool appropriate data making hypothetical comparisons more congruent. For example, pain in the medial OR lateral patella zones of the PKPM was compared to localised OR regional patella pain recorded by Thompson et al.’s method [12].

### 2.5. Reliability assessment

Reliability is the ability of a measure to produce the same results with repeated assessment [14]. In this study, this was subdivided into test–retest between participants after a delay and inter-rater/ intra-rater reproducibility for observers scoring the completed PKPM. To generate a reliability cohort the PKPM was posted by mail to 63 patients, with a short explanation and return envelope. This was done a fortnight prior to their attendance at a specialist knee clinic. Immediate post surgical patients and arthroplasty follow up patients

<table>
<thead>
<tr>
<th>Group</th>
<th>Validity cross section* (n = 35)</th>
<th>Reliability testing cohort† (n = 58)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnosis</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Osteoarthritis</td>
<td>15</td>
<td>42.9%</td>
</tr>
<tr>
<td>Meniscal pathology</td>
<td>9</td>
<td>25.7%</td>
</tr>
<tr>
<td>Patellofemoral pathology</td>
<td>4</td>
<td>11.4%</td>
</tr>
<tr>
<td>Cruciate ligament injury</td>
<td>3</td>
<td>8.6%</td>
</tr>
<tr>
<td>Extensor tendinopathy</td>
<td>1</td>
<td>2.9%</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>3</td>
<td>8.6%</td>
</tr>
<tr>
<td>Normal knee</td>
<td>0</td>
<td>0.0%</td>
</tr>
</tbody>
</table>

A cohort† of 44 patients who marked 58 knees.

![Fig. 3.](image3.png) The PKPM template was generated to classify pain location into nine localised anterior zones. The margins of the template are congruent with the PKPM to facilitate accurate placement.

![Fig. 4.](image4.png) The template was placed over the PKPM to define the anterior zone boundaries (LJLA, lateral joint line area; SL, superior lateral; MJLA, medial joint line area; SM, superior medial; QT, quadriceps tendon; LP, lateral patella; MP, medial patella; PT, patella tendon; and T, tibia).

![Fig. 5.](image5.png) Histogram showing which diagram patients selected as the best knee representation (n = 39). The size of each bar represents the number of patients who selected each diagram.

![Table 1](image1.png) Range of knee pathologies seen in the two patient groups: A cross section* of 26 patients who marked 35 knees.
were excluded. Forty seven responses were received of which three patients did not attend the clinic. The cohort of 44 attending responders completed a second PKPM at the clinic. Twenty three patients were male and 21 were female. They ranged in age from 17 to 86 (mean of 41) and presented with the knee pathologies shown in Table 1. Test–retest reproducibility was assessed by calculating agreement between zones where the two completed PKPM had been scored by the same observer. The delay between consecutive PKPM completions was less than 24 h in four patients and so these PKPM were excluded from the test–retest analysis.

It was then possible to score all of the PKPM collected in the whole study by observers blinded to previous recordings. This included the PKPM collected from the cross section of 26 patients and the two forms completed by the cohort of 44 attending responders; in total 70 patients. Inter-rater reproducibility was assessed by calculating agreement between the PKPM scored by two distinct observers. Intra-rater reproducibility was assessed by calculating agreement between the PKPM scored by the same observer after a delay of six months.

2.6. Statistical analysis

Statistical advice was obtained from a statistician. Agreement levels were assessed using Cohen’s Kappa statistic [15]. The kappa coefficient, k, expresses agreement beyond the level that can be attributed to chance alone. When interpreting agreement other authors [16] have grouped k values with the following descriptive terms; “very good” with k values of 0.81–1.0, “good” for 0.61–0.8, “moderate” for 0.41–0.6, “fair” for 0.21–0.4 and “poor” for 0.01–0.2. The significance level adopted was 95% and the software used for statistical processing was Statistical Package for Social Sciences version 18 (SPSS Inc., Chicago, Illinois).

3. Results

3.1. Patient sample

The opinions of 39 patients were sampled using the diagrams in Fig. 1, with the results shown in Fig. 5. Twenty six (66.7%) patients selected the photographic representation (Fig. 1D) as the best knee representation. Nine (23.1%) chose the coloured anatomical diagram (Fig. 1A), three (7.7%) selected Fig. 1B and one (2.5%) chose Fig. 1C.

3.2. Independent opinion on template zones

Validity ratios calculated according to Lawshe’s method are presented in Table 2, where values greater than 0.37 signify adequate validity [13]. The highest ratios (0.84) were found for the medial joint line area and the patella tendon. Ratios for the remaining zones ranged from 0.28 to 0.76. The quadriceps tendon (0.28) did not exceed the threshold of adequacy (0.37).

3.3. Validity testing

A cross section of twenty six patients provided data, nine of whom chose to mark locations on the PKPM bilaterally giving data for a total of 33 knees. Seventeen of these patients indicated pain locations on just one knee (8 right and 9 left). Consistencies between the PKPM and Thompson et al.’s method [12] are shown in Table 3. There was very good agreement (k = 0.88, p<0.001) for the posterior knee. Agreement was moderate to good (k = 0.47, p<0.003 to k = 0.62, p<0.001) for zones on the lateral side. On the medial side this was fair to moderate (k = 0.37, p<0.005 to k = 0.54, p<0.001). Centrally the tibia showed good agreement (k = 0.64, p<0.001) and the patella moderate agreement (K = 0.49, P = 0.003). There were no zones in Thompson et al.’s map [12] which would hypothetically match with either the quadriceps tendon or patella tendon zones of the PKPM. Agreement (k = 0.27, P = 0.059) was found between the PKPM quadriceps tendon and Thompson et al.’s [12] lateral joint line. There was poor agreement (k = 0.17, P = 0.267) between the PKPM patella tendon and
Table 4
Test–retest, inter-rater and intra-rater reproducibility rates were assessed.

<table>
<thead>
<tr>
<th>Localised zone</th>
<th>Test–retest (n = 52)</th>
<th>Inter-rater (n = 151)</th>
<th>Intra-rater (n = 151)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Freq1†</td>
<td>Freq2†</td>
<td>Kappa Agreement</td>
</tr>
<tr>
<td>posterior knee</td>
<td>14</td>
<td>10</td>
<td>0.72 good</td>
</tr>
<tr>
<td>lateral joint line area</td>
<td>26</td>
<td>22</td>
<td>0.62 good</td>
</tr>
<tr>
<td>superior lateral</td>
<td>10</td>
<td>11</td>
<td>0.70 good</td>
</tr>
<tr>
<td>medial joint line area</td>
<td>27</td>
<td>27</td>
<td>0.46 moderate</td>
</tr>
<tr>
<td>superior medial</td>
<td>12</td>
<td>11</td>
<td>0.39 fair</td>
</tr>
<tr>
<td>quadriceps tendon</td>
<td>7</td>
<td>6</td>
<td>0.56 moderate</td>
</tr>
<tr>
<td>lateral patella</td>
<td>26</td>
<td>27</td>
<td>0.65 good</td>
</tr>
<tr>
<td>medial patella</td>
<td>25</td>
<td>26</td>
<td>0.73 good</td>
</tr>
<tr>
<td>patella tendon</td>
<td>25</td>
<td>19</td>
<td>0.46 moderate</td>
</tr>
<tr>
<td>tibia</td>
<td>10</td>
<td>10</td>
<td>0.51 moderate</td>
</tr>
</tbody>
</table>

n is the number of knees marked on the PKPM that were included in each distinct analysis. Reported for each PKPM zone are: frequencies when pain was recorded as present, agreement calculated using Cohen’s kappa [15] and interpretive descriptors [16] of this agreement. All results were significant p < 0.0001.

† Frequencies reported by second observer (DWE).

Patients (Table 1). Therefore, future use of the PKPM in patients with similar knee pathologies is appropriate. Knee arthroplasty patients were excluded and so further study will be required to establish if the PKPM can be applied to this patient group.

The authors developed the template by consensus after considering previous examples from the literature [8–12]. Our rationale was to include common sites of knee pain, whilst mapping the underlying anatomical structures as closely as possible. We acknowledge that opinions will differ as to where the margins of each zone should lie. However, to generate the template a final decision on boundary positioning was necessary. Consequently it is anticipated that adjacent zones will have the closest association with regional pain patterns. To confirm the relevance of the zones in the template, independent opinion was canvassed on the perceived importance of each anatomical zone. The panel of subject matter experts were based at a different hospital and had no prior involvement with the PKPM development in order to minimise subjective bias. The validity ratios demonstrated adequacy for all but one of the zones, because the panel believed that pain identification in these zones has sufficient importance to justify measurements. However, the quadriceps tendon zone did not exceed the adequacy threshold (0.37) where fewer panel members indicated its importance. We believe this was a consequence of the typically low frequency of quadriceps tendon pain (11.9% in one study [11]).

Having spent time considering underlying structures we believe that the PKPM template of zones is a fair anatomical representation. This may make the PKPM more purposeful in facilitating the diagnostic process; however we acknowledge that this paper has not specifically explored the performance of the PKPM as a diagnostic tool. Further studies comparing pain location to arthroscopic findings are planned and may establish predictive value of the PKPM. We envisage that the PKPM will be a useful tool in studies exploring natural changes in pain location and changes that may occur after physiotherapy or surgical interventions.

Validity testing compares the components of an instrument with a hypothetical match [14]. We acknowledge the limitations in instrument design when a gold standard for comparison is yet to be established. However, the process needs to start somewhere and accordingly Thompson’s knee pain map [12] was considered to be the closest theoretical match for comparison. Significant agreement was found not for the patella tendon or quadriceps tendon because there were no hypothetically matched zones in Thompson’s map [12]. Conversely, where zones had more obvious logical comparisons then the analysis demonstrated patterns of convergent validity (Table 3). Therefore, interpreting the PKPM to be valid is reasonable because it is capable of locating pain presence in the same sites as the compared measure (Thompson’s map [12]).

Thompson et al.’s [12] patella or patella region. Neither of these results was statistically significant.

3.4. Reliability assessment

The reliability cohort comprised 44 patients, 14 of whom chose to mark locations on the PKPM bilaterally giving data for a total of 58 knees. Thirty of these patients indicated pain locations on just one knee (11 right and 19 left). The sampling period between completion of the first and second PKPM ranged from several hours to 14 days (mean of 6.6 days) with a distribution shown in Fig. 6. Four patients (6 knees) had a sampling delay of less than 24 h and hence were excluded from test–retest analysis which was performed upon the PKPM from 40 patients (52 knees). Test–retest reproducibility rates are reported in Table 4 from fair to good (K = 0.39 to 0.73, P < 0.0001). When the completed PKPM from the cross section and the two forms from the cohort were scored again, a total of 151 knees (35 + 58 + 58) had been marked. Inter-rater reproducibility was good to very good (k = 0.77 to 0.97, P < 0.0001) and intra-rater reproducibility was very good (k = 0.81 to 1.0, P < 0.0001).

4. Discussion

The aim of this study was to develop an instrument capable of recording the location of knee pain which was both valid and reliable. The PKPM was not designed to record any facet of knee pain other than location. It is intended for use as an aid in diagnosis, communication and research.

During initial instrument development patient opinion was canvassed. The majority of patients (66.7%) indicated that a photograph was the clearest representation of a pair of knees. This ensured that a photographic model was at least recognisable to the majority of patients which is why it was selected for further refinement. When the developed PKPM was used on patients it remained understandable and all patients were able to complete the instrument. When this event was witnessed in clinical settings, completion occurred without significant delay or difficulty, suggesting low patient burden. The PKPM is a two-dimensional map and so it does not encompass the realism that three-dimensional models may impart. However, an interesting observation was made that several patients using the PKPM chose to rest the paper map over the skin of their own knees in order to gauge positions. It appears that this two-dimensional model is capable of being interpreted appropriately by clinical patients (Table 1).
Reliability is the ability of a measure to produce the same results with repeated assessment [14]. The PKPM demonstrated reproducibility rates which were fair to good for test–retest, good to very good for inter-rater and very good for intra-rater. When compared to the reliability rates described by Thompson et al. [12], test–retest reproducibility was similar and inter-rater reproducibility was better. Intra-rater reproducibility was not reported by Thompson et al. [12]. These findings suggest that the method of reading the location of marks though a congruent acetate template is readily reproducible between observers and by the same observer.

Research suggests that patients recall the location of pain more accurately than frequency or intensity [17]. Therefore short sampling delays may allow recall bias [17] to influence reporting and this was avoided by excluding these patients. Alternatively longer time frames may introduce a systematic bias if pain location has naturally changed. Research suggests that chronic knee pain is often punctuated by short episodes of more intense pain [18]. We hypothesised that if the intensity of knee pain can change over time then its location may also change. Consequently, a long sampling delay was forestalled by posting the first PKPM no earlier than a fortnight before the clinic appointment.

In conclusion, this paper is the first to present a knee pain map that reports instrument generation, validity and reliability. This study has supported the hypothesis that the photographic knee pain map (PKPM) is a valid and reliable instrument for determining knee pain location. It is anticipated that the PKPM will prove to be a useful research tool as further work examines the relationships between pain location, pathological processes and surgical interventions. The PKPM is available at: www.photographickneepainmap.com.

5. Conflict of interest

Re: The photographic knee pain map: Locating knee pain with an instrument developed for diagnostic, communication and research purposes.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

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References


