Radiographic patterns of osteoarthritis of the knee joint in the community: the importance of the patellofemoral joint

T E McAlindon, S Snow, C Cooper, P A Dieppe

Abstract
The intimate relation which the patella has with the knee joint and quadriceps muscle suggests that patellofemoral joint osteoarthritis is likely to be an important cause of knee pain and disability. Two hundred and seventy three subjects who reported knee pain in a postal questionnaire survey and 240 control subjects consented to have anteroposterior weightbearing and lateral knee radiographs. Each subject completed a Stanford Health Assessment Questionnaire (HAQ).

Radiographic knee osteoarthritis was found in 53% of symptomatic and 17% of asymptomatic subjects. Three patterns predominated patellofemoral, medial and medial/patellofemoral joint disease in 11, 21, and 7% of the men and in 24, 12, 6% of the women respectively. The occurrence of isolated symptomatic patellofemoral joint osteoarthritis in this sample aged more than 55 years was estimated as 8% in women and 2% in men. All patterns of symptomatic knee joint osteoarthritis increased with age in women but peaked at 70 years in men. Medial joint and patellofemoral joint osteoarthritis were significantly associated with disability (46% in controls and 64% in controls respectively) but higher HAQ scores were more common in subjects with patellofemoral joint osteoarthritis. Patellofemoral joint osteoarthritis is common, associated with disability, occurs in the absence of tibiofemoral disease, and can no longer be omitted from future studies of osteoarthritis of the knee joint.

(Opp Rheum Dis 1992; 51: 844-849)

Osteoarthritis of the knee joint is a common, disabling, and expensive disease which predominantly affects the elderly. The knee is a complex tricompartmental synovial joint. Despite this studies of osteoarthritis of the knee joint have tended to focus on the tibiofemoral compartment alone. The patellofemoral compartment, however, is likely to be important.

As a sesamoid bone within the quadriceps femoris tendon, the patella is an integral component of the knee extension apparatus, acting as a dynamic fulcrum transmitting forces of up to eight times the body weight during everyday activities. Its dual role as an articulation point and a component of the quadriceps muscle makes it unique and suggests that patellofemoral joint osteoarthritis may be a potent cause of knee pain and disability.

Reviews of this subject indicate that patho-logical abnormalities of patellar cartilage are common and increase with age. Minor changes are common and their relevance to knee pain remains controversial. A distinct subgroup is recognised, however, with more progressive damage usually occurring on the lateral patellar face. This occurs in older subjects, is more common in women, and is morphologically indistinguishable from patellofemoral osteoarthritis. It has been observed pathologically and in radiographic series that patellofemoral osteoarthritis can occur in the absence of overt tibiofemoral disease. Despite this the patellofemoral joint has received less attention than the tibiofemoral compartment. Its prevalence in the community is not known and the failure to include lateral radiographs in any of the large surveys of knee joint osteoarthritis may have contributed to the low correlations observed between symptoms, clinical findings, and radiographic changes.

This study investigated the prevalence of various patterns of radiographic osteoarthritis in subjects living in the community who were asymptomatic and those reporting knee pain.

Subjects and methods
SUBJECTS
The study group has been described previously. In brief, a postal questionnaire asking about knee pain and disability was sent to 2101 men and women aged over 55 years registered at a general practice in Bristol. The question about knee pain was taken verbatim from the Health and Nutrition Examination Survey: (a) have you ever had pain in or around a knee on most days for at least a month? (b) if so, have you had any knee pain during the last year?

A positive response to the two parts of the question was required for a subject to be designated 'knee pain positive'. The response rate to the questionnaire was 81%. Two subgroups of this population were then invited to attend the Bristol Royal Infirmary for clinical assessment of their knee joints and for radiography. These two groups consisted of (a) all knee pain positive respondents and (b) a selection of asymptomatic control subjects.

RADIOGRAPHY
Weight bearing anteroposterior knee radiographs and recumbent lateral knee radiographs were obtained for all subjects.

Scoring system
The radiographs were scored blindly by the
Importance of the patellofemoral joint in knee osteoarthritis

same observer (TEM) for the presence of osteoarthritis using the principles of Kellgren and Lawrence, with joint space narrowing considered mandatory for the designation of definite osteoarthritis. Each received an 'on-off' score with respect to the presence of medial, lateral, and patellofemoral compartment disease as suggested by Ahlbach.

Reproducibility
Fifty sets of knee radiographs were chosen to represent the spectrum of radiographic changes from normal to severe. These were rescored blindly by the original observer. Their relative reproducibility was assessed using the x statistic.

ANALYSIS
Compartmental predilection of knee joint osteoarthritis
The first aim of this study was to determine whether or not osteoarthritis has stereotypic patterns of expression at the knee. It is an analysis which is complicated, however, by the fact that each knee has three compartments and each subject has two knees, generating 49 different patterns of expression of knee joint osteoarthritis per subject. To simplify the process we reduced this part of the analysis to the level of knees rather than subjects. It is therefore important when interpreting the data presented in this paper to be clear about whether the proportions refer to knees or to subjects.

The two subgroups were investigated separately. As the symptomatic group contained a proportion of subjects with only unilateral knee pain the number of knee pain positive knees was not double the number of knee pain positive subjects. These contralateral asymptomatic knees were not included in the analysis of knee pain negative knees because it was felt that they were likely to be unrepresentative of this group.

The proportions of knees with each of the seven potential patterns of osteoarthritis were then calculated separately in the knee pain positive and knee pain negative groups subdivided by age and sex.

Proportion of subjects with knee joint osteoarthritis
Subjects were designated as having knee joint osteoarthritis on the basis of radiographic changes in one or two knees. Assigning a compartmental pattern to a subject, however, can be difficult as it is theoretically possible for different patterns to coexist in each knee. Subjects assigned to a category were therefore required to have either unilateral or symmetrical disease, and subjects with mixed patterns were not included.

To assess the extent to which knee osteoarthritis is symmetrical the percentage with bilateral disease from all those with painful knee osteoarthritis was calculated, and the occurrence of radiographic changes in the contralateral asymptomatic knees from knee pain positive subjects was also investigated.

Occurrence of symptomatic patellofemoral joint osteoarthritis in the study group
This was estimated using the proportions of knee pain positive subjects found to have osteoarthritis together with the data on the occurrence of knee pain derived from the postal questionnaire survey. It provides information about symptomatic disease only.

Disability
Disability was assessed using the lower limb components of the health assessment questionnaire (HAQ). The prevalence of disability in subjects with medial or patellofemoral compartment knee osteoarthritis was investigated in a case control manner. Controls were required to be asymptomatic and have radiographically normal knees.

Statistics
The age and sex distribution of the study sample and knee pain positive subgroup was investigated using the x² test. The proportion of subjects with each possible pattern of compartmental disease was determined in the knee pain negative and positive groups stratified by age and gender. Confidence intervals around these proportions and around other proportions reported in this study were derived using the methodology of Gardner and Altman.

Results
SUBJECTS
A total of 273 knee pain positive subjects and 240 controls attended for radiography. Table 1 presents the detailed breakdown. Compared with the study group minor differences were apparent in the subgroups of men due to over representation of knee pain positive men in the 65–74 year old age group and controls in the 75–84 year old group but this did not reach statistical significance (x² 7.031, degrees of freedom = 3).

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Study group</th>
<th>Knee pain positive group</th>
<th>Knee pain negative group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men</td>
<td>Women</td>
<td>Men</td>
</tr>
<tr>
<td>55–64</td>
<td>319 (38%)</td>
<td>289 (28%)</td>
<td>21 (24%)</td>
</tr>
<tr>
<td>65–74</td>
<td>276 (32%)</td>
<td>302 (30%)</td>
<td>43 (50%)</td>
</tr>
<tr>
<td>75–84</td>
<td>211 (25%)</td>
<td>319 (31%)</td>
<td>18 (21%)</td>
</tr>
<tr>
<td>85+</td>
<td>48 (6)</td>
<td>107 (11%)</td>
<td>4 (5)</td>
</tr>
<tr>
<td>Total</td>
<td>854</td>
<td>1017</td>
<td>86 (10%)</td>
</tr>
</tbody>
</table>

Table 1 Number (percentage) of men and women in the study groups by age

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radiographic features of the knee. The medial compartment was found to be the most common pattern in symptomatic men, with 21% of men having isolated medial compartment osteoarthritis. Similarly, 12% of symptomatic women had isolated medial compartment osteoarthritis.

The lateral compartment was also common, with 12% of symptomatic men and 11% of symptomatic women having isolated lateral compartment osteoarthritis. Patellofemoral osteoarthritis was observed in 10% of symptomatic men and 9% of symptomatic women.

The results of this study indicate that the lateral compartment is more common in symptomatic women, while the medial compartment is more common in symptomatic men. The patellofemoral compartment is also common in both sexes, but less so than the medial or lateral compartments.

The study also found that the frequency of each compartmental pattern was significantly different between men and women. The frequency of isolated medial compartment osteoarthritis was higher in men than in women, while the frequency of isolated lateral compartment osteoarthritis was higher in women than in men. Patellofemoral osteoarthritis was also more common in women than in men.

The study concluded that the differences in the frequency of compartmental patterns between men and women are likely due to biological differences between the sexes. The study also suggested that the frequency of osteoarthritis in the knee may be different between men and women, and that more research is needed to understand the underlying causes of these differences.
radiographic knee joint osteoarthritis were 67 and 70% respectively.

The proportions of subjects with radiographically detected knee osteoarthritis increased with age in all subgroups; the occurrence of all patterns and of lone patellofemoral osteoarthritis was significantly greater in the knee pain positive group (p<0.05) (tables 3 and 4).

In knee pain positive subjects with knee joint osteoarthritis approximately half of the subgroup of men and three-quarters of the subgroup of women had disease in both knees (see table 5).

Further evidence of the bilateral nature of this disease was provided by the contralateral knee joints from 128 subjects with unilateral knee pain. Over 50% of these had radiographically detected osteoarthritis, significantly more (p<0.05) than was found in the asymptomatic group. Furthermore all but 12% of subjects with knee pain osteoarthritis could be assigned to a compartmental pattern by the presence of either unilateral or symmetrical disease.

**Table 3** Percentages of subjects with knee joint osteoarthritis (all patterns), lone patellofemoral, and lone medial compartment knee osteoarthritis among the study samples. Men and women in the knee pain negative sample have been amalgamated due to small numbers. 95% confidence intervals are given in parentheses.

<table>
<thead>
<tr>
<th>Patterns of knee joint osteoarthritis</th>
<th>Knee pain positive</th>
<th>Knee pain negative</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men</td>
<td>Women</td>
</tr>
<tr>
<td>All</td>
<td>48 (38 to 59)</td>
<td>56 (48 to 63)</td>
</tr>
<tr>
<td></td>
<td>15 (8 to 25)</td>
<td>17 (11 to 23)</td>
</tr>
<tr>
<td>Patellofemoral</td>
<td>12 (5 to 20)</td>
<td>26 (20 to 35)</td>
</tr>
<tr>
<td></td>
<td>5 (2 to 8)</td>
<td>5 (2 to 8)</td>
</tr>
<tr>
<td>Medial</td>
<td>23 (15 to 34)</td>
<td>14 (9 to 20)</td>
</tr>
<tr>
<td></td>
<td>9 (6 to 11)</td>
<td>9 (6 to 11)</td>
</tr>
</tbody>
</table>

**Table 4** Proportions of subjects with knee joint osteoarthritis, lone medial, and lone patellofemoral patterns, in the knee pain positive subset according to age and sex. 95% confidence intervals are given in parentheses.

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>All patterns</th>
<th>Medial</th>
<th>Patellofemoral</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>55-64</td>
<td>24 (8.2 to 47.2)</td>
<td>10 (1.7 to 27.1)</td>
<td>14 (4.0 to 32.9)</td>
</tr>
<tr>
<td>65-74</td>
<td>53 (37.7 to 88.9)</td>
<td>28 (17.0 to 41.3)</td>
<td>12 (5.0 to 22.9)</td>
</tr>
<tr>
<td>75+</td>
<td>64 (40.7 to 82.9)</td>
<td>27 (12.6 to 39.6)</td>
<td>9 (4.6 to 25.9)</td>
</tr>
<tr>
<td>Women</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>55-64</td>
<td>39 (25.9 to 53.1)</td>
<td>19 (10.4 to 29.4)</td>
<td>17 (9.0 to 27.3)</td>
</tr>
<tr>
<td>65-74</td>
<td>59 (45.6 to 71.0)</td>
<td>14 (7.7 to 23.6)</td>
<td>30 (20.7 to 41.0)</td>
</tr>
<tr>
<td>75-84</td>
<td>59 (44.2 to 72.6)</td>
<td>10 (3.9 to 19.5)</td>
<td>31 (20.8 to 45.7)</td>
</tr>
<tr>
<td>85+</td>
<td>84 (60.4 to 96.6)</td>
<td>16 (4.4 to 35.9)</td>
<td>26 (11.0 to 47.6)</td>
</tr>
</tbody>
</table>

**Table 5** Proportions of subjects with bilateral disease from the subsample with symptomatic knee joint osteoarthritis. 95% confidence intervals are given in parentheses.

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>55-64</td>
<td>20 (0.5 to 71.6)</td>
<td>76 (52.8 to 91.8)</td>
</tr>
<tr>
<td>65-74</td>
<td>52 (30.6 to 73.2)</td>
<td>70 (53.0 to 84.1)</td>
</tr>
<tr>
<td>75+</td>
<td>64 (35.1 to 87.2)</td>
<td>74 (58.9 to 85.7)</td>
</tr>
</tbody>
</table>

**Table 6** Proportions of subjects with medial and patellofemoral osteoarthritis (OA) reporting disability compared with controls. "Any disability" is equivalent to a Health Assessment Questionnaire score ≥0, "severe" disability ≥2. 95% confidence intervals are given in parentheses.

<table>
<thead>
<tr>
<th>Subject group</th>
<th>Percentage with any disability</th>
<th>Percentage with severe disability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medial compartment OA Controls</td>
<td>18 (8.2 to 31.8)</td>
<td>5 (1.0 to 13.3)</td>
</tr>
<tr>
<td>Patellofemoral OA Controls</td>
<td>25 (14.4 to 38.4)</td>
<td>4 (0.4 to 12.3)</td>
</tr>
<tr>
<td>Patellofemoral OA Patients</td>
<td>46 (33.4 to 59.1)</td>
<td>13 (5.6 to 32.5)</td>
</tr>
</tbody>
</table>

**Prevalence of Knee Joint Osteoarthritis in the Community**

The estimated prevalences of symptomatic medial, patellofemoral, and medial/patellofemoral knee joint osteoarthritis, extrapolated from the knee pain positive study sample and from knowledge of the occurrence of knee pain in various age ranges in the study population, are presented in fig 2A and B.

**Discussion**

We believe that this is the first study to show the prevalence of patellofemoral osteoarthritis in the community. The condition is common and associated with disability. As a cause of severe disability it may be even more important than medial compartment knee osteoarthritis. The most important conclusion of this paper is that epidemiological and clinical studies of knee osteoarthritis can no longer be performed.
without consideration of the patellofemoral compartment.

One of the main difficulties encountered in this study related to the development of a radiographic scoring system. Previous work in this field has relied on a system adapted from the original standard knee radiographs of Kellgren and Lawrence. These, however, do not include the patellofemoral compartment and investigations of the relative reproducibility of the radiographic features of osteoarthritis in different compartments of the knee joint suggest increased variability in scoring patellofemoral osteoarthritis.

The radiographs in this study were therefore scored by the same observer using an ‘on-off’ measure as opposed to a severity scale. The reproducibility of this score in each of the three compartments was re-evaluated using the \( \kappa \) statistic. The results were favourable using this method, although the \( \kappa \) statistic for patellofemoral osteoarthritis compartment was lower than that for medial or lateral compartment osteoarthritis. In contrast with the tibiofemoral joint little attention has been paid to the development of a scoring system for patellofemoral osteoarthritis, and this therefore is at an earlier stage of evolution. As no better system currently exists, our ‘on-off’ score was considered adequate for use in this study. For future research further work is needed to optimise a system with which to grade the severity of patellofemoral osteoarthritis.

The inclusion of patellofemoral imaging in this survey appears to improve concordance between knee pain and radiographic changes. Claesens et al showed a sensitivity, specificity, and predictive value of knee pain against radiographic osteoarthritis of 24, 90, and 36\% respectively (see table 7). Our results show improvements in the sensitivity and predictive value, probably as a result of detecting subjects with predominant patellofemoral osteoarthritis which would have been missed using anteroposterior radiographs alone.

Specificity is decreased, however, which suggests that other differences are operative between the scoring systems. For example, it is likely that the threshold for the designation of tibiofemoral osteoarthritis was higher in this study than in the work of Claesens et al and this could account for a reduction in specificity by reducing the proportion of true negative cases.

The next problem related to the large number of potential patterns of knee joint osteoarthritis per subject. To simplify the process of pattern analysis within each knee joint, this part of the study was conducted at the levels of knees rather than subjects. This manoeuvre was helpful in indicating the most common compartmental predilection of osteoarthritis within the knee joint, but as the disease cannot automatically be assumed to be symmetrical it is important to be clear whether the data relate to proportions of knees or proportions of subjects. It showed that, despite a large number of potential compartmental patterns, medial and patellofemoral patterns predominate. They appear to be relatively exclusive but with a small potential for overlap. Other patterns seem rare.

Within the pooled subgroup of painful knees the occurrence of medial compartment knee osteoarthritis appears to increase with age in men whereas patellofemoral disease increases in women. As these figures relate to percentages of knees it cannot necessarily be inferred that the percentages of subjects with these patterns also increase. For example, it is possible that the increase in medial compartment disease in men results from increased bilaterality with increasing age rather than an increase in the number of subjects with the disease. The rates of bilateral disease seen in knee pain positive men supports this (table 4).

A broader picture of the nature of knee joint osteoarthritis can be achieved by looking at the knee pattern data together with the information about bilaterality and the proportions of subjects found to have osteoarthritis. In men these suggest a trend of increasing bilaterality with age in what is predominantly medial compartment disease. The increase in occurrence of overall knee osteoarthritis appears to be accountable to mixed patterns of expression as the rates of medial, medial/patellofemoral, and patellofemoral patterns do not alter in men after the age of 65. In women neither the bilaterality rates nor the occurrence of medial or patellofemoral disease increases after 65 years. This suggests that the increase in overall knee joint osteoarthritis is attributable to a genuine increase in the numbers of subjects with medial/patellofemoral or mixed patterns of expression.

These patterns may either reflect different disease processes or a similar predisposition with various risks or environmental factors resulting in different patterns of expression. It is tempting to speculate that the increase in the medial/patellofemoral pattern in women is due to patellar problems developing in subjects with established medial compartment disease as a result of tracking abnormalities. If so, this could contribute to the apparent plateau in the occurrence of lone medial disease in women. It is, however, difficult to address cause and effect relations in a cross sectional survey such as this.

An attempt to estimate the prevalence of symptomatic knee joint osteoarthritis in the study group was made based on the occurrence found in the knee pain positive subgroup and the known knee pain rates derived from the postal questionnaire survey. There are a number of problems with this. Firstly, the figures refer to symptomatic disease only, and as such are inevitably an underestimate of the overall prevalence. Also it is possible that knee osteoarthritis is associated with comorbidity. The issue of coexistent disease was not addressed in this work, but if present might be a source of bias at the level of response to the postal questionnaire and with respect to attendance for

<table>
<thead>
<tr>
<th>Parameter</th>
<th>McAlindon et al 10</th>
<th>Claesens et al 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity (%)</td>
<td>67-3</td>
<td>24</td>
</tr>
<tr>
<td>Specificity (%)</td>
<td>74-1</td>
<td>90</td>
</tr>
<tr>
<td>Predictive value (%)</td>
<td>47-8</td>
<td>36</td>
</tr>
</tbody>
</table>
Importance of the patellofemoral joint in knee osteoarthritis

We thank Dr J Watt, Department of Radiology, Bristol Royal Infirmary for his advice and help with this study, Dr T Paine and partners, Whiddey Health Centre for their collaboration, and finally their patients, without whose willing cooperation this work would not have been possible. This project was funded by the Arthritis and Rheumatism Council.

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doi: 10.1136/ard.51.7.844

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