The knee skyline radiograph: its usefulness in the diagnosis of patello-femoral osteoarthritis

R. Bhattacharya · V. Kumar · E. Safawi · P. Finn ·
A. C. Hui

Received: 24 February 2006 / Revised: 28 March 2006 / Accepted: 30 March 2006 / Published online: 17 June 2006
© Springer-Verlag 2006

Abstract The aim of this study was to determine the usefulness of the skyline radiograph in the diagnosis of patellofemoral osteoarthritis. Additionally, we wanted to assess the usefulness of patello-femoral crepitus as a clinical sign of this condition. Seventy-seven patients scheduled to undergo knee surgery had standard antero-posterior, lateral and skyline X-rays of their affected knee. The presence of clinical patello-femoral crepitus was also documented preoperatively. At the operation, their patello-femoral joints were graded into two groups according to the presence or absence of osteoarthritis. The lateral and skyline view X-rays as well as patello-femoral crepitus were compared individually against the operative findings. The skyline view had a sensitivity of 79% and a specificity of 80%. The lateral view had a sensitivity of 82% and specificity of 65%. Patello-femoral crepitus as a sign had a sensitivity of 89% and a specificity of 82%. There was no statistically significant difference between the two radiological views in terms of sensitivity and specificity in the diagnosis of patellofemoral osteoarthritis. Hence, we cannot recommend the skyline view as a routine radiological investigation in all cases of suspected patellofemoral osteoarthritis.

Résumé Le but de cette étude était de déterminer l'utilité des vues axiales de rotule dans le diagnostic de l'arthrose patellofémorale. Le signe du rabot peut également être utile et est un signe clinique habituel dans ce type de lésions. Soixante-dix-sept patients, préparés pour bénéficier d'une prothèse totale du genou ont bénéficié de radios antéropostérieure du genou, de radios de profil et d'une vue axiale de rotule. La présence d'un rabot patello fémoral a également été indiquée en préopératoire. A l'intervention, les lésions patello fémorales ont été classées en deux groupes, en fonction de la présence ou de l'absence de l'arthrose. La vue de profil de la vue axiale de rotule et des lésions fémoro patellaires ont été comparées. La vue axiale de rotule a une sensibilité de 79% et une spécificité de 80%. Le cliché de profil a une sensibilité de 82% et une spécificité de 65%. Le signe du rabot a une sensibilité de 89% et une spécificité de 82%. Il n'y a pas de différences significatives entre tous ces clichés radiologiques en termes de sensibilité et spécificité lors du diagnostic d'une arthrose fémoro patellaire. De ce fait, nous ne recommandons pas de pratiquer une vue axiale de rotule comme bilan de routine dans les cas suspects d'arthrose fémoro patellaires.

R. Bhattacharya · V. Kumar · E. Safawi · A. C. Hui
The James Cook University Hospital,
Marton Road,
Middlesbrough TS4 3BW, UK

P. Finn
School of Health and Social Care, University of Teesside,
Tees Valley,
TS1 3BA Middlesbrough, UK

V. Kumar (✉)
32, Grosvenor Road,
Billingham, Cleveland TS22 5HA, UK
e-mail: geobug@gmail.com

Introduction

Concerning the recent emphasis on the patello-femoral joint as an important component of knee osteoarthritis (OA), the jury is out with regard to the requirement of further radiological investigations for this compartment. It has been argued for some time that the lateral view does not give optimum information with regard to the status of the patellofemoral joint in the diagnosis of OA [16] and is capable of over- or under-representing the extent of OA changes in that joint [1]. The skyline or axial view has long been known to provide useful information about the

Table 1 Outerbridge classification system for osteoarthritis [5]

Grade	Criteria
0	Normal
1	Articular cartilage softening and swelling
2	Fragmentation and fissuring in an area less than 12 mm (half-inch) diameter
3	Fragmentation and fissuring in an area greater than 12 mm (half-inch) diameter
4	Erosion of cartilage to subchondral bone

morphology and anatomy of the patellofemoral joint [1, 2, 16]. As a result, it has been suggested that this view is also likely to be more sensitive than the lateral view in assessing patellofemoral OA, allowing more precise localisation of any degenerative change [23].

Some recent studies have claimed to confirm the suggestion that the skyline view is a more useful diagnostic tool than the lateral film in the assessment of patellofemoral OA [6, 8, 11, 13]. However, none of these studies have compared the lateral and skyline views to a gold standard. There have been studies in the past that have used operative findings as the standard to calculate the sensitivity and specificity of different radiographs [19] and to assess the reliability of OA classification systems [3]. However, the comparison has never been made between knee lateral and skyline views using this standard. There have also not been any previous studies, to our knowledge, objectively assessing patello-femoral crepitus as a useful clinical sign in the diagnosis of patello-femoral OA.

A recent survey of orthopaedic surgeons in the UK has shown that over 70% do not use the skyline view in their routine investigation for knee OA [24]. The question is, does this constitute a deviation from the best practice?

Materials and methods

Our study was designed as an observational, method comparison trial involving a cohort of patients who had

Table 2 Kellgren and Lawrence classification system for osteoarthritis [9]

Grade	Criteria
0	Normal
1	Doubtful narrowing of joint space; possible osteophyte formation
2	Definite osteophytes; absent or questionable narrowing of joint space
3	Moderate osteophytes; definite narrowing; some sclerosis; possible joint deformity
4	Large osteophytes; marked narrowing; severe sclerosis; definite joint deformity

Table 3 Comparison of patello-femoral crepitus with operative findings

		Operative finding (gold standard)		
		OA present	OA absent	Total
Patellofemoral crepitus	OA present	48	4	52
	OA absent	6	19	25
	Total	54	23	77

been offered surgery for knee pain. The aim was to reflect current clinical practice and to determine whether the skyline view was really a necessity in the realistic clinical situation.

With advice from a statistician, the sample size was generated using Stata Statistical Software [22], and the required sample size was calculated as 75 subjects.

To eliminate inter-observer variation in the opinions with regard to the presence or absence of OA, the study was planned as a single observer exercise, with one specific consultant surgeon with sub-specialist expertise in knee disorders checking clinically for patello-femoral crepitus and performing the operative gradings as well as the radiological gradings.

The study population was comprised of patients with complaints of knee pain attending the outpatient clinic of the senior surgeon. All patients who had not had any previous knee surgery and who were listed for either an arthroscopic or an open knee procedure were approached and enrolled in the study after giving their consent. Pregnant patients were excluded. All the patients had standard antero-posterior and lateral views and additionally a skyline view of their affected knee joint.

As the skyline view is not routinely used in our clinical practice, ethical approval was sought, and the study received full ethical committee approval.

The antero-posterior views were taken with the patient bearing weight in full extension. The lateral views were mid-flexion views, which in our hospital are normally standardised with the use of a supporting wedge. The skyline view chosen was the one with the knee flexed to 45 degrees as proposed by Merchant [17].

The operative classification in our study was the Outerbridge system [18] (Table 1). The Kellgren and Lawrence grading system [12] (Table 2) was used for grading the X-rays, since studies have shown that it is as good as [3, 21], if not better [20] than, other systems of radiological classification of OA.

All patients had the presence or absence of patello-femoral crepitus documented on presentation to the clinic. When the patients underwent surgery, the consultant graded their patellofemoral compartment changes under direct vision using the Outerbridge system. The patients were

Table 4 Summary of results

	Skyline view	Lateral view	Patellofemoral crepitus
Sensitivity	81% (71 to 92%)	83% (73 to 93%)	89% (80 to 97%)
Specificity	61% (41 to 81%)	39% (19 to 59%)	83% (67 to 98%)
Positive predictive value	83% (73 to 93%)	76% (65 to 87%)	92% (85 to 100%)

Percentages rounded off to the nearest whole number

Values in parentheses indicate the 95% confidence intervals

divided into two dichotomous groups. All normal joints were classed as “OA absent”. All patellofemoral joints that had any of the features representing Outerbridge’s grade 1 or above were classed as “OA present”.

After a prolonged gap following surgery, the skyline and lateral views of the operated patients were separately presented to the consultant in a random order, after removing all patient details.

All X-rays that had no OA features in the patellofemoral compartment were classed as “OA absent”. All the X-rays that had any of the features representing Kellgren and Lawrence grade 1 or above in the patellofemoral compartment were classed as “OA present”. Once all the gradings had been obtained, the data was analysed by comparing the readings of the skyline and lateral views as well as the presence of patello-femoral crepitus individually against the operative findings.

We calculated the sensitivity and the specificity values for the two X-rays and the crepitus, compared separately against the operative finding, which was regarded as the gold standard.

Although the positive predictive values were calculated, with the subjects being selected from an outpatient population already complaining of knee pain, the possibility of a sampling bias was high, and thus the positive predictive values are likely to be invalid for the general population.

Results

The period of study ranged from August 2003 to March 2004. A total of 83 patients were recruited for this study. However, six of the patients had at least one preoperative X-ray of poor quality, which could not be read well. Hence these cases were not used in the final statistical calculations. The results were thus calculated for the remaining 77 patients. There were 42 male and 35 female patients. The average age for the study group was 51.5 years (range 17 to 87 years), with the average for males being 46.2 years (range 18 to 83 years) and for the females 58.2 years (range 17 to 87 years). There were 34 left knees and 43 right knees undergoing operation. Forty-seven of the knees had an

arthroscopic procedure and 30 knees had some form of knee joint replacement.

Fifty-four of the knees were found to have features of patellofemoral OA at the operation. Fifty-nine of the 77 patients were assessed as having patellofemoral OA on the lateral films, whereas the skyline films reported 53 of the 77 patients as having patellofemoral OA. Using patellofemoral crepitus as a diagnostic sign, 52 patients were diagnosed as having patello-femoral OA. Cross tabulation was performed comparing the operative findings to the lateral films, the skyline films and patello-femoral crepitus (Table 3) individually.

The sensitivity of the lateral film was 83% and the skyline film 81%. The specificity was 39% for the lateral film and 61% for the skyline film. The positive predictive value was 76% for the lateral film and 83% for the skyline film. Patello-femoral crepitus not surprisingly had a high sensitivity of 89% and specificity of 83% and a positive predictive value of 92%. The detailed results including the respective confidence intervals are summarised in Table 4 and Figs. 1, 2 and 3.

The figures show that the skyline view has a slightly lower sensitivity, but a higher specificity compared to the lateral film. However, it is obvious from Table 4 and the graphs that follow that the 95% confidence intervals of the sensitivity and specificity of the two films overlap over a wide margin. This implies that none of the differences are statistically significant. The study thus fails to show any superiority of the skyline view over the lateral view in the diagnosis of patellofemoral OA. It does, however, show that the presence of crepitus as a clinical sign is as good as, if not better than, the X-ray views at diagnosing patellofemoral OA.

Discussion

Claims of the advantages of the skyline view in diagnosing anatomical and morphological disorders of the patellofemoral joint have led to the assumption that it also could be a useful tool in the diagnosis of patellofemoral OA. However, there have been no formal studies to assess any benefits of the skyline view until the last decade when a

Fig. 1 Sensitivity with 95% confidence intervals of the two X-rays

few studies were reported. The big drawback in all these studies was the lack of any comparisons with gold standards. Sometimes “knee pain” was used as denoting OA [6], whereas at other times the two views were compared with each other [8] to calculate these values, which clearly cannot give a true sensitivity or specificity of either.

It is evident from the results of this study that the skyline view confers no additional advantage when compared to the lateral view in the diagnosis of patellofemoral OA. A closer inspection of the studies that favour the skyline view [6, 11, 13] shows that although it provides a more reproducible and subtle measure of joint space narrowing, when it comes to observing the other features of OA (osteophyte formation, cysts and sclerosis), the advantages are not as obvious.

Although the inter- and intra-observer variation studies provide an estimate of the reliability of the radiographs, none of these studies actually address the issue of the validity of the films. The skyline view may be more consistent in reporting joint space narrowing, but this does not necessarily equate with OA of the joint. An advantage of our study is that this issue of validity has been addressed by visualising the actual joint directly and then comparing it with the radiological findings.

Fig. 2 Specificity with 95% confidence intervals of the two X-rays

Fig. 3 Positive predictive value with 95% confidence intervals of the two X-rays

In previous studies, there has been an increased and sometimes almost singular emphasis placed on joint space narrowing as a form of grading OA. This seems to have stemmed from the fact that the World Health Organisation has endorsed joint space narrowing as the principle outcome measure for measuring disease progression in trials for slow-acting drugs in osteoarthritis [15]. However, comparisons with operative findings have shown poor correlation between joint space narrowing and its clinical counterpart, i.e., articular cartilage damage [10]. Papers that have claimed joint space narrowing to be the most reproducible feature in the assessment of radiographs for OA have also acknowledged that in patello-femoral assessment joint space narrowing is not as reliable as in the case of tibiofemoral assessment [7]. Variation of knee flexion is known to affect joint space width assessed on the skyline view [4], and there are other studies that have shown that joint space narrowing is not as reliable as other methods of diagnosing OA [3, 20].

There is also a lack of consensus with regard to the definition of a “normal” joint space. Although Ahlback [1] described this “normal” space as 3 mm or less, community studies have shown that a value of 3 mm for a normal joint space yields a very poor sensitivity of only 25% for detecting OA symptoms, and even increasing the cut off to 4 mm only improves the sensitivity to 37% [14]. To be accurate, the measurements have to be made with callipers and with reference to fixed radiographic anatomical landmarks, which again vary with the various studies. Due to this and other logistical factors, it is unfortunately, not always possible to measure joint space accurately in each individual film in the everyday clinical setting. It has also been reported that joint space narrowing estimated by eye has a poor inter-observer reliability, more so in the patellofemoral compartment than the tibiofemoral compartment [7]. In reality, there is less reliance placed on joint space narrowing as a means of diagnosing patellofemoral

OA in the clinical setting. Radiological osteophytes have been shown to be significantly better at predicting symptoms of knee OA compared to joint space narrowing [5]. Joint space narrowing obviously has a role in defining radiological OA, but only in association with other features [9]. This study uses the Kellgren and Lawrence grading system [12] for the diagnosis of patellofemoral OA as it does not place emphasis on any single feature, but is a more global classification incorporating all the radiological features of OA.

It is interesting that over 75% of orthopaedic surgeons in the UK choose not to obtain skyline views in the diagnosis of OA of the knee [24]. However, more than 95% of the same group of surgeons use this view in cases of patellar instability, and over 80% use it for anterior knee pain. Of the surgeons who use the skyline view for the diagnosis of OA, there is no consensus of opinion on the optimal angle of flexion. This underlines the fact that the skyline view may not be as useful for the OA knee in the clinical setting as claimed in some of the studies.

In most cases, radiographers regularly perform antero-posterior and lateral knee films, but not skyline views. Hence, for any study involving the skyline views, it is likely that emphasis will be placed on this technique as compared to the standard lateral techniques in any training sessions, and this may well create bias. There is a possibility that different skyline knee flexion angles during radiography may contribute to artificial joint space changes in different studies [13]. Our study used the Merchant's view [17] of 45-degree knee flexion essentially because this was the view with which the radiographers in our hospital were most familiar and therefore most competent without any additional training sessions.

The current study also has its own limitations. As in previous studies, there is an inherent sampling bias due to the selection of patients from the outpatient clinic. The two grading systems used in the study, i.e., the Outerbridge system [18] and the Kellgren and Lawrence system [12], although used widely, have never been formally assessed by any study to check their reliability and validity. Hence, the use of these classification systems themselves may have produced errors in the study. It has also been presumed that arthroscopy is as good as open visualisation in the diagnosis of OA. Although seemingly reasonable, no formal studies exist in the literature to validate this assumption.

By enrolling patients undergoing open knee surgery only, the possibility of errors arising from arthroscopic diagnosis can be eliminated in future studies. The development of a validated classification system that accurately correlates the various OA grades at the operation with OA grades on radiological examination would be an invaluable tool both for research purposes as well as for future clinical studies.

Conclusion

It is generally acknowledged that it can be difficult to obtain images of the patellofemoral joint in a consistent manner without a highly trained technician. For clinical evaluation and population studies, it is important to choose views that maximally detect radiographic OA, are cost effective and yield technically satisfactory films. The skyline view seems to provide no additional benefit compared to the lateral film in the diagnosis of patellofemoral OA. Indeed, properly elicited patello-femoral crepitus would seem to be of much more value.

Further larger methodically sound studies from different centres are required to provide more conclusive evidence regarding the efficacy of skyline films in knee OA, but based on this study, the skyline view cannot be recommended to be incorporated routinely in the standard radiological investigation of suspected knee OA.

Acknowledgements We would like to extend our sincere gratitude to Dr. R. Campbell, Consultant Radiologist at The James Cook University Hospital for arranging to partially fund the project through the radiology department, and to Professor Stothard, Consultant Orthopaedic Surgeon at The James Cook University Hospital, for his support and advice throughout the project.

References

1. Ahlback S (1968) Osteoarthritis of the knee. A radiographic investigation. *Acta Radiol [Suppl]* 277:1–72
2. Beaconsfield T, Pintore E, Maffulli N, Petri GJ (1994) Radiological measurements in patellofemoral disorders. *Clin Orthop Relat Res* 308:18–28
3. Brandt KD, Fife RS, Braunstein EM, Katz B (1991) Radiographic grading of the severity of knee osteoarthritis: relation of the Kellgren and Lawrence grade to a grade based on joint space narrowing, and correlation with arthroscopic evidence of articular cartilage degeneration. *Arthritis Rheum* 34(11):1381–1386
4. Brattstrom H (1964) Roentgen examination of the distal femur end and the femoro-patellar joint by so called axial picture. *Acta Orthop Scand* 68[Suppl]:53–78
5. Cicuttini FM, Baker J, Hart DJ, Spector TD (1996) Association of pain with radiological changes in different compartments and views of the knee joint. *Osteoarthritis Cartilage* 4(2):143–147
6. Cicuttini FM, Baker J, Hart DJ, Spector TD (1996) Choosing the best method for radiological assessment of patellofemoral OA. *Ann Rheum Dis* 55:134–136
7. Cooper C, Cushnaghan J, Kirwan JR, Dieppe PA, Rogers J, McAlindon T, McCrae F (1992) Radiographic assessment of the knee joint in osteoarthritis. *Ann Rheum Dis* 51:80–82
8. Davies AP, Vince AS, Shepstone L, Donell ST, Glasgow MM (2002) The radiological prevalence of patellofemoral OA. *Clin Orthop Relat Res* 402:206–212
9. Felson DT, McAlindon TE, Anderson JJ, Naimark A, Weissman BW, Aliabadi P, Evans S, Levy D, LaValley MP (1997) Defining radiographic osteoarthritis for the whole knee. *Osteoarthritis Cartilage* 5(4):241–250
10. Fife RS, Brandt KD, Braunstein EM, Katz BP, Shelbourne KD, Kalasinski LA, Ryan S (1991) Relationship between arthroscopic evidence of cartilage damage and radiographic evidence of joint

- space narrowing in early osteoarthritis of the knee. *Ann Rheum Dis* 34:377–382
11. Jones AC, Ledingham J, McAlindon T, Regan M, Hart D, MacMillan PJ, Doherty M (1993) Radiographic assessment of patellofemoral OA. *Ann Rheum Dis* 52:655–658
 12. Kellgren JH, Lawrence JS (1957) Radiological assessment of osteoarthritis. *Ann Rheum Dis* 16:494–501
 13. Lanyon P, Jones A, Doherty M (1996) Assessing progression of patellofemoral OA: a comparison between two radiographic methods. *Ann Rheum Dis* 55:875–879
 14. Lanyon P, O'Reilly S, Jones A, Doherty M (1998) Radiographic assessment of symptomatic knee OA in the community: definitions and normal joint space. *Ann Rheum Dis* 57:595–601
 15. Lequesne M, Brandt K, Bellamy N, Moskowitz R, Menkes CJ, Pelletier J-P (1994) Guidelines for testing slow acting drugs in osteoarthritis. *J Rheumatol* 21[Suppl 41]:65–73
 16. Merchant AC (2001) Patellofemoral imaging. *Clin Orthop Relat Res* 389:15–21
 17. Merchant AC, Mercer RL, Jacobsen RH, Cool CR (1974) Roentgenographic analysis of patellofemoral congruence. *J Bone Joint Surg Am* 56 A:1391–1396
 18. Outerbridge RE (1964) The etiology of chondromalacia patellae. *J Bone Joint Surg Br* 46:752–757
 19. Rosenberg TD, Paulos LE, Parker RD (1988) The 45-degree posteroanterior flexion weight-bearing radiograph of the knee. *J Bone Joint Surg Am* 70:1479–1483
 20. Spector TD, Hart DJ, Byrne J, Harris PA, Dacre JE, Doyle DV (1993) Definition of osteoarthritis of the knee for epidemiological studies. *Ann Rheum Dis* 52:790–794
 21. Scott WW Jr, Lethbridge-Cejku M, Reichle R, Wigley FM, Tobin JD, Hochberg MC (1993) Reliability of grading scales for individual radiographic features of osteoarthritis of the knee. The Baltimore longitudinal study of aging atlas of knee osteoarthritis. *Invest Radiol* 28(6):497–501
 22. StataCorp (2001) Stata statistical software: release 7.0. College Station, TX: Stata Corporation
 23. Thomas RH, Resnick D, Alazraki NP, Daniel D, Grenfield R (1975) Compartmental evaluation of osteoarthritis of the knee. *Radiology* 116:585–594
 24. Vince AS, Singhania AK, Glasgow MMS (2000) What knee X-rays do we need? A survey of orthopaedic surgeons in the United Kingdom. *The Knee* 7:101–104