Assessing progression of patellofemoral osteoarthritis: a comparison between two radiographic methods

Peter Lanyon, Adrian Jones, Michael Doherty

Abstract

***Objective*—To compare two plain radiographic methods for sensitivity to detect progression of patellofemoral osteoarthritis.**

***Methods*—Two sets of paired skyline and lateral knee radiographs from 54 hospital referred patients (108 knees) with knee osteoarthritis were taken an average of 31 months apart (range 12-40). Films were examined separately in random order by a single observer blind to patient identity and time order. Minimum joint space was measured by metered caliper; individual features of osteoarthritis were graded 0-3 using an atlas.**

***Results*—Intraobserver reproducibility assessed on 40 knees was to within ±0.5 mm for skyline lateral facet and ±0.7 mm for medial facet and lateral views. On the lateral view measured joint space decreased in 51% of knees but increased in 43%, with overall no significant mean group change with time (−0.2 mm, 95% confidence interval, 0.1 to −0.5). By contrast on the skyline view joint space decreased in at least one facet in 71% of knees, with significant decrease in mean joint space for both lateral facets (−0.4 mm, 95% CI, −0.2 to −0.6) and medial facets (−0.5 mm, 95% CI, −0.1 to −0.8).**

***Conclusions*—It is possible to detect significant joint space loss with time on the skyline view that is not apparent on the lateral view. The skyline view should be the method of choice to detect progression of patellofemoral osteoarthritis.**

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The importance of the patellofemoral joint (PFJ) as a common site of osteoarthritis has only recently been emphasised.[1] Although most knee osteoarthritis grading systems and outcome studies have concentrated on tibiofemoral joint involvement, there may be a stronger association between PFJ osteoarthritis and pain and disability.[1] Radiographic assessment of joint space narrowing has recently been endorsed by ILAR and WHO as the principal outcome measure for measuring disease progression in trials of slow acting drugs in osteoarthritis.[2] The evidence that loss of joint space width reliably reflects cartilage thickness is accumulating.[3] While studies of the tibiofemoral joint have suggested that a cartilage loss of 0.2-0.3 mm per year may occur in osteoarthritic knees,[2] such information is not currently available for the PFJ. Indeed, the best plain radiographic method with which to assess and measure progression in the PFJ has not been determined.

The mid-flexion lateral radiograph has been the most widely used method, but has poor reproducibility for assessment of joint space narrowing[4] and it has been suggested that it is of little value in detecting osteoarthritis progression.[5] Recently, more accurate and reproducible methods of measuring PFJ space on lateral radiographs have been proposed,[6 7] but despite using these methods Speake *et al* were unable to detect any significant progression in joint space narrowing over three years.[7]

The tangential skyline view of the knee[8] may provide a more reproducible assessment of the PFJ than the lateral view,[9 10] but its sensitivity to detect disease progression in comparison with the lateral view is not known. This study was therefore undertaken to compare the skyline and lateral views for sensitivity to change in order to determine the preferred radiographic method for detecting progression of patellofemoral osteoarthritis.

Methods

PATIENTS

Patients with knee osteoarthritis attending a hospital rheumatology clinic who had undergone both lateral and skyline radiographs at two time points at least one year apart were selected for study. Those who had undergone knee joint replacement or in whom the patella could not be assessed due to poor radiographic technique were excluded.

While all patients had hospital referred knee osteoarthritis, the study population was a heterogeneous group and not selected on the basis of a particular pattern of compartmental involvement or disease severity.

RADIOGRAPHIC ASSESSMENT

Lateral radiographs were taken in mid-flexion (55 kV, 8 mA s^{-1}, FSD 100 cm). There is a variety of techniques for obtaining skyline views[8 11 12]; in this study these were taken according to the method of Laurin in 30° of flexion[8] (60 kV, 10 mA s^{-1}, FSD 100 cm). All radiographs were assessed blind by a single observer (PL) in random patient and time order. Each pair of knees was assessed at the same time; lateral and skyline views were assessed independently of each other on

Rheumatology Unit, City Hospital, Hucknall Road, Nottingham NG5 1PB, United Kingdom
Peter Lanyon
Adrian Jones
Michael Doherty

Correspondence to:
Dr Peter Lanyon.

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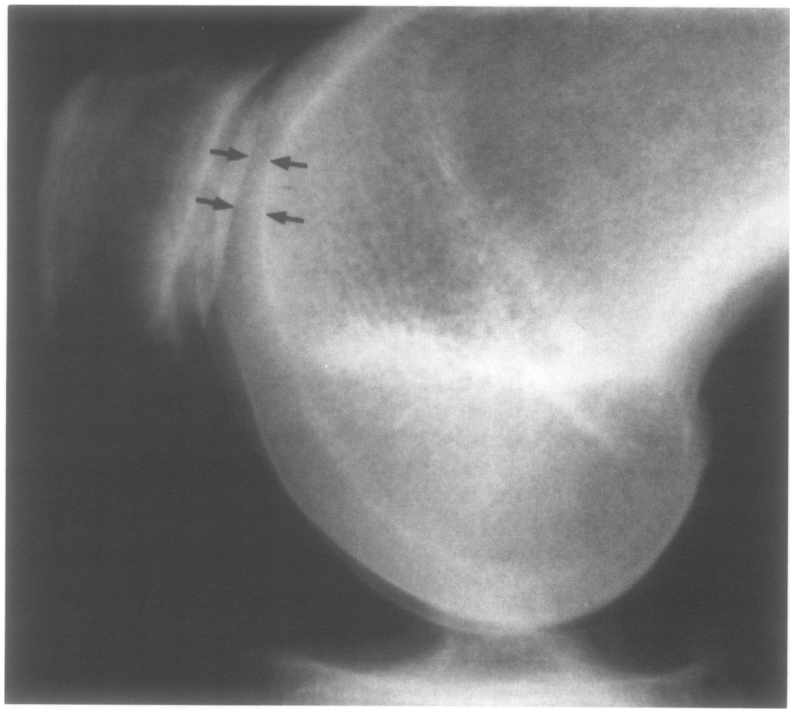

Figure 1 Lateral knee radiograph: arrows identify the articular margins for measurement of minimum and mid-patellar joint space.

separate occasions. Measurements of joint space were performed by hand to the nearest 0.1 mm using a metered dial caliper (RS Components, Switzerland).

On lateral radiographs, features of osteoarthritis were graded visually according to a published atlas.[13] Joint space narrowing, sclerosis, and osteophyte were each graded on a 0-3 scale. Knee flexion was measured to the nearest 5° using a goniometer. Lateral joint space was measured according to two proposed methods: a mid-patellar joint space perpendicular from the posterior ridge of the patella at its mid-point to the femoral intercondylar groove, and a minimum joint space at the narrowest point between the posterior ridge of the patella and the intercondylar groove[7] (fig 1).

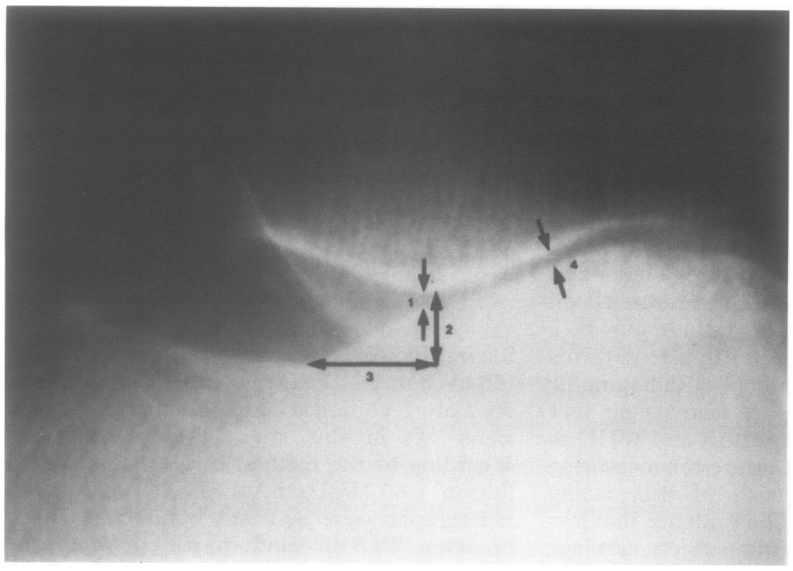

Figure 2 Skyline radiograph showing lateral subluxation: arrows identify the articular margins for measurement of (1) apex minimum joint space, (2) apex sulcus joint space, (3) lateral subluxation distance, (4) lateral facet minimum joint space.

Skyline radiographs were graded according to a published atlas.[14] For each facet, joint space narrowing, patellar osteophyte, and femoral osteophyte were individually graded 0-3; sclerosis 0-1; and medial and lateral subluxation 0-1 and 0-3, respectively. Minimum joint space in each facet was measured from the bright radiodense band of subchondral cortex on the patella to the articular margin of the femoral cortex.[6] Measurements of joint space at the apex were also made because it was felt that this might provide an assessment comparable to the mid-patellar joint space on the lateral radiograph. Two apical measurements were made: from the patellar apex to the nearest perpendicular point on the femur (apex minimum distance), and from the apex perpendicular to a point on a line running parallel to the femoral condyles through the base of the intercondylar sulcus (apex sulcus distance)—see fig 2. These two measurements were expected to be equivalent unless patellar subluxation was present. In knees where either lateral or medial subluxation was apparent, a subluxation distance was measured (fig 2).

STATISTICAL ANALYSIS

To assess reproducibility, 80 knees (40 skyline, 40 lateral) were rescored by the same observer one week after initial assessment. Level of agreement was quantified using the κ statistic,[15] and reproducibility of continuous variables was assessed using the method of Bland and Altman.[16] Confidence intervals were calculated according to standard methods.[17]

Results

After excluding radiographs of four patients (two because of knee replacement, two because of poor film quality), complete sets of paired lateral and skyline radiographs of 108 knees (54 patients, 15 male, 39 female, mean age 71 years, range 38 to 84) were available for analysis. The mean time interval between films was 31 months (range 12 to 42 months).

REPRODUCIBILITY

Skyline lateral facet joint space was the most reproducible of all measurements (95% confidence interval ±0.5 mm) (table 1). On the lateral view, measurement of minimum patellar joint space was more reproducible than mid-patellar joint space (95% CI ±0.7 mm and ±1.1 mm, respectively). Reproducibility of graded joint space was also higher on the skyline view (table 2). Reproducibility for osteophyte was generally lower than narrowing on both views.

LATERAL VIEW

At baseline, mean knee flexion was 63°, with a trend towards smaller joint spaces being seen with greater degrees of flexion (fig 3). There was a small but non-significant increase in mean knee flexion of 2° (±4) over time. Thirty four knees (31%) had joint space narrowing at baseline (grade ≥2) and 52 (48%) osteophytosis (grade ≥ 2 at any site). With time, 18 knees

Table 1 Reproducibility of joint space measurements (40 knees)

	Reproducibility (95% confidence intervals[15])
Lateral view	
Flexion angle	± 9 degrees
Min patellar joint space	± 0.7 mm
Mid patellar joint space	± 1.1 mm
Skyline view	
Lateral facet joint space	± 0.5 mm
Medial facet joint space	± 0.7 mm
Apex min joint space	± 0.9 mm
Apex sulcus joint space	± 0.7 mm
Lateral subluxation distance	± 0.9 mm
Medial subluxation distance	± 0 mm

Table 2 Unweighted kappa values for reproducibility of grading

Lateral view	*Kappa*		*Pa*	
Joint space narrowing	0.68		0.78	
Osteophyte-inferior patellar	0.55		0.7	
Osteophyte-superior patellar	0.8		0.85	
Osteophyte-superior femoral	0.43		0.6	
	Lateral facet		*Medial facet*	
Skyline view	*Kappa*	*Pa*	*Kappa*	*Pa*
Joint space	0.88	0.93	0.96	0.98
Osteophyte-femoral	0.56	0.7	0.74	0.83
Osteophyte-patellar	0.55	0.7	0.55	0.7
Sclerosis	1	1	1	1
Subluxation	0.65	0.88	1	1

Pa, proportion of actual agreement

(17%) increased in grade and 22 decreased (20%). The mean minimum and mid-patellar joint spaces at baseline and their change with time are shown in table 3. Minimum and mid-patellar joint space decreased in 53 (51%) and 55 (49%) knees respectively. However, in 46 (43%) there was an increase, with overall no significant mean change. When a change in grade of narrowing was seen, this was matched by an appropriate change in joint space measurement in 80% of cases. There were no significant changes in osteophyte size with time.

SKYLINE RADIOGRAPHS

At baseline, 29 knees (27%) showed narrowing in either facet and 81 (75%) osteophytosis (grades ≥ 2). With time, 33 knees (31%) increased in grade in one or both facets and 15 (14%) decreased. The baseline mean values for joint space measurements and their change with time are shown in table 3. A decrease in either lateral or medial facet joint space was seen in 71 knees (71%). Overall there was significant mean joint space narrowing at both lateral (−0.4 mm, 95% CI −0.2 to −0.6 mm), medial facet (−0.5 mm, 95% CI −0.1 to −0.8 mm), and apex (−0.5 mm, 95% CI −0.1 to −0.8 mm). There was no significant association between the degree of change and the joint space measurement at baseline. In knees where a change in narrowing grade was observed, this was matched by an appropriate change in measured joint space in 87% of cases. Among a subgroup of 40 knees which had no joint space narrowing (grade 0) in either facet at baseline, joint space decreased with time in both facets in 19 knees (48%), decreased in one facet while increasing in the

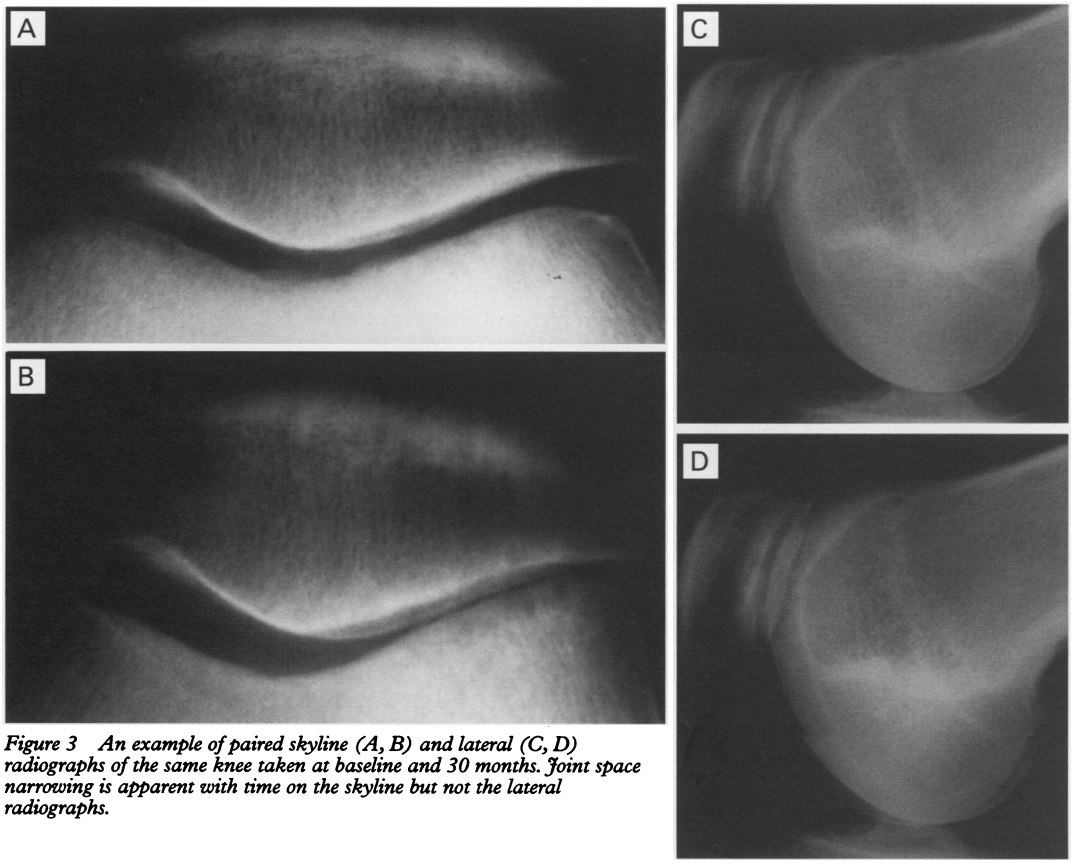

Figure 3 An example of paired skyline (A, B) and lateral (C, D) radiographs of the same knee taken at baseline and 30 months. Joint space narrowing is apparent with time on the skyline but not the lateral radiographs.

other in 11 knees (28%), and increased in both facets in 10 knees (25%). There was no significant change in osteophyte size with time.

Subluxation was present more frequently in the lateral than medial facet (31 and 7 knees respectively), and with time lateral subluxation distance increased in 25 knees, with an overall mean increase of 0.5 mm. In only one of the 25 knees where lateral subluxation increased was there an observed increase in skyline lateral facet joint space. However, on the lateral view of these knees there was widening of the minimum and mid-patellar joint space in 14 knees (56%) and 19 knees (76%), respectively.

Discussion

In 54 patients with knee osteoarthritis, over a mean period of 31 months we have been able to detect significant progression of osteoarthritic features in the patellofemoral compartment from serial skyline radiographs. This progression was not apparent from lateral radiographs. The magnitude of mean minimum joint space loss (0.4 mm lateral facet, 0.5 mm medial facet) observed over an average 31 months is equivalent to a loss of 0.16-0.19 mm per year, similar to that reported to occur in hospital referred symptomatic patients with hip and tibiofemoral osteoarthritis (0.2-0.3 mm per year).[2] The method we used to manually measure joint space (fine pointed metered dial caliper) proved simple and quick and had good reproducibility.

Assessing progression of joint space narrowing from skyline radiographs using visual comparison to an atlas grade was specific but less sensitive to change than direct measurement. However, on the skyline view visual assessment of narrowing using a recent atlas[14] appears more reproducible and more sensitive to change than a comparable grading system on the lateral view.[13]

The inability of lateral radiographs to detect any significant change in minimum joint space is in keeping with a previous study in which the authors postulate that their inability to detect change was possibly due to a decrease in knee flexion with time masking any true joint space narrowing.[7] Although our study had very similar mean minimum lateral joint space and flexion angle at baseline to that of Speake *et al* (4.7 mm and 4.5 mm, 62° and 64° respectively), we observed, in contrast, a small decrease in mean knee flexion with time. The expected effect of this, if any, would be to produce apparent joint space narrowing.

Table 3 Mean baseline joint space measurements and change with time (108 knees)

	Original n=108	*Progression n=108*	*95% confidence intervals*[15]
Lateral view			
Flexion angle	62°	2°	+6, −2
Min patellar joint space	4.7 mm	−0.2 mm	+0.1, −0.5 mm
Mid patellar joint space	5.4 mm	−0.1 mm	+0.3, −0.4 mm
Skyline view			
Lateral facet joint space	3.9 mm	−0.4 mm	−0.2, −0.6 mm
Medial facet joint space	4.9 mm	−0.5 mm	−0.1, −0.8 mm
Apex min joint space	4.9 mm	−0.5 mm	−0.2, −0.8 mm
Apex sulcus joint space	5.4 mm	−0.4 mm	−0.1, −0.8 mm
Lateral subluxation distance	1.2 mm	−0.5 mm	+0.8, +0.2 mm
Medial subluxation distance	0.2 mm	−0.1 mm	+0.3, −0.1 mm

An alternative explanation for the relative insensitivity of the lateral view to detect progression of joint space narrowing is the role of patellar subluxation. Although this is often difficult to appreciate, it has been included in a recent standard atlas,[14] and can be assessed with good reproducibility. Patellar subluxation was initially observed in 38 of 108 knees, most commonly in the lateral facet. In 25 knees where an increase in lateral subluxation (measured distance) was seen over time, the lateral facet joint space increased in only one knee. By contrast on the lateral radiographs of these knees, widening of both the mid- and minimum patellar joint space was frequently observed. It is therefore possible that patellar subluxation may negate accurate measurement of joint space on lateral radiographs by altering the alignment of the intercondylar groove and the posterior part of the patella such that they are no longer in the same vertical plane.[7] Failure to adequately address this issue is a basic flaw of studies attempting to determine progression from lateral films alone.[7]

Variation of knee flexion is known to affect joint space width assessed on the skyline view.[11] It is not possible to determine knee flexion angle from skyline radiographs. Although the procedure for taking skyline views did not vary during the period of this study, we cannot discount the possibility that a different skyline knee flexion angle may have contributed to "artificial" joint space change. However, any such effect would be expected to be random and equally likely to produce joint space widening as narrowing. The reproducibility of the skyline *x* ray technique compared to the lateral view in individual patients is not known, but such study would involve repeated *x* ray exposure which may not be ethical.

This study was confined to hospital referred patients, all of whom had osteoarthritis in at least one compartment of at least one knee. This population therefore had the advantage of a likelihood of change in either knee occurring over a relatively short time period. Despite the relatively small number of patients, they comprised a spectrum of all grades of severity, and the study time period was sufficient to demonstrate change. In those knees where both skyline facet joint spaces were initially graded as normal, narrowing of both facets was detected in 48% and in one facet in 25% over time. It therefore seems likely that the skyline view may also be more useful than the lateral to determine progression in community based studies.

Despite detecting joint space narrowing, we have not detected any change in osteophyte grade. In tibiofemoral osteoarthritis, joint space narrowing has previously been suggested to be of greater value than osteophytosis in assessing progression.[5] Our results suggest that this may also be the case in the patellofemoral compartment.

In conclusion, we have shown that it is possible to detect significant progression in joint space narrowing on skyline radiographs which is not apparent on the lateral view. Failure to account for patellar subluxation might explain

why the lateral view does not detect progression in a similar time period.[7] The skyline view should be the preferred plain radiographic method to assess the progression of patellofemoral osteoarthritis.

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Since MD is Editor of the journal, Dr John Axford served as acting editor to ensure impartial review of this paper.

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