Comparison of Patella Cartilage Volume and Radiography in the Assessment of Longitudinal Joint Change at the Patellofemoral Joint

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ABSTRACT. ***Objective.*** To compare radiological assessment of the patellofemoral (PF) joint and cartilage volume as measured by magnetic resonance imaging (MRI) in a longitudinal study.

Methods. One hundred and two subjects with osteoarthritis (OA) had baseline and followup skyline and lateral radiographs and MRI of the same knee. Duration of followup was 1.94 ± 0.23 years. Mid-patella joint space and narrowest joint space were measured on lateral PF radiographs. Minimum joint space in the lateral and medial facets was measured on skyline radiographs. Rate of progression of PF joint OA was measured quantitatively at each site. Patella cartilage volume was measured from the MRI. The rate of change in each radiographic measure was compared to the rate of change in patella cartilage volume.

Results. The average loss of patella cartilage was 133 ± 143 μm^3/yr (4.4%). The loss of joint space over the same period on lateral radiographs was 0.7 ± 2.6 mm at the narrowest joint space and 0.2 ± 3.8 mm at the mid-patella joint space. On the skyline radiographs, the loss of joint space at the medial facet was 0.4 ± 3.9 mm and 0.2 ± 3.4 mm at the lateral facet. Only change in narrowest joint space on the lateral PF radiographs correlated with change in patella cartilage volume (R = 0.22, p = 0.03).

Conclusion. Our data suggest that narrowest joint space measured on lateral PF radiographs correlates best with loss of patella cartilage. Further work will be needed to determine how different radiological measures of the PF joint relate to the disease process in OA. (J Rheumatol 2004; 31:1369–72)

Key Indexing Terms:
PATELLA CARTILAGE RADIOLOGICAL ASSESSMENT LONGITUDINAL CHANGE

Osteoarthritis (OA) is a common cause of disability in people aged over 65 years[1]. Symptomatic OA of the knee has been shown to be commonly related to patellofemoral (PF) disease and may even require joint replacement[2-4]. However, very little is known about the rate of progression of PF joint OA or the optimum method for determining this. One study compared skyline and lateral radiographs and suggested that skyline radiographs were more sensitive for detecting progression[5]. However, there is evidence that lateral radiographs may also be useful for measuring progression in PF OA[6].

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There has been increasing interest in the use of magnetic resonance imaging (MRI) in the measurement of knee cartilage volume as a possible outcome measure in arthritis[7-9]. Measurement of patella cartilage has been shown to be a valid measure of cartilage volume when MRI cartilage volume is compared to anatomical dissection and to be reproducible with coefficient of variations of less than 5%[7-9]. MRI assessment of the joint has potential advantages compared to radiographs in that joint cartilage is directly visualized and the whole 3-dimensional structure can be examined. The 3-dimensional measurement is less likely to be influenced by repositioning, which is important in longitudinal studies. We have recently shown that patella cartilage is lost at the rate of about 4% per annum[10]. No studies have compared radiographic assessment of the PF joint and measurement of patella cartilage volume in the assessment of disease progression in OA of the PF joint. With the increasing interest in direct visualization and measurement of articular cartilage it is important to compare these measures to interpret results of studies using different imaging modalities.

We examined a cohort of patients with predominantly mild to moderate symptomatic knee OA over 2 years, to compare the change in patella cartilage volume to the

change in joint space narrowing as measured from skyline and lateral radiographs of the PF joint.

MATERIALS AND METHODS

Patient selection. Patients were recruited by using a combined strategy including advertising in local newspapers and the Victoria branch of the Arthritis Foundation of Australia as well as collaboration with general practitioners, specialist rheumatologists, and orthopedic surgeons. The study was approved by the ethics committee of the Alfred and Caulfield Hospitals, Melbourne, Australia. All patients gave informed consent. Subjects aged 40 years or more who fulfilled American Rheumatology Association (ARA) clinical and radiographic criteria for OA knee were examined[11]. Subjects were excluded if any other form of arthritis was present, if there were contraindications to MRI, or if a total knee replacement was planned.

Radiographic evaluation. Each subject had an MRI performed on the symptomatic knee at baseline and approximately 2 years later. Where both knees were symptomatic and had OA, the knee with least severe radiographic OA was used. Knees were imaged in the sagittal plane on the same 1.5-T whole-body MR unit (Signa Advantage HiSpeed, GE Medical Systems, Milwaukee, MI, USA) using a commercial receive-only extremity coil as described[9,12]. Patella cartilage volume was determined by image processing on an independent workstation using the Osiris software (University of Geneva). We used a matrix of 512 × 512 pixels, resulting in an in-plane resolution of 0.31 mm × 0.31 mm. Contours were drawn around the patella in images 1.5 mm apart on sagittal views. MRI cartilage volume was measured blinded regarding the time sequence of the MRI. The coefficient of variation (CV) was 2.1% for patella cartilage volume[9,12]. The coefficient of variation when an individual was repositioned in the MRI machine was 2.3%.

The following radiographic views of the PF joint were obtained at baseline and approximately 2 years later: (1) a standing lateral (mediolateral) view in 30° flexion, and (2) a skyline (inferosuperior) view in 45° flexion using a perspex positioning wedge, with the subject supine[13]. All radiographs were independently assessed by one trained observer who was blinded to the sequence of the radiographs and to the MRI findings. On lateral radiographs, osteophytes and joint space narrowing were graded[13]. Lateral joint space was measured in duplicate, by a single observer, according to 2 methods: (1) a mid-patella joint space perpendicular from the posterior ridge of the patella at the mid-point to the femoral intercondylar groove; and (2) a narrowest joint space at the narrowest point between the posterior ridge of the patella and the intercondylar groove[5,6]. The mean of the duplicate readings was used. The coefficients of variation as a measure of the reproducibility of these measures were joint space at the mid-point 3.1% and narrowest joint space 4.4%.

Skyline radiographs were graded for joint space narrowing and osteophytes[13]. Minimum joint space in the lateral and medial facets was measured in duplicate, by a single observer, from the bright radiodense band of subchondral cortex on the patella to the articular margin of the femoral cortex, as described[5]. The mean of duplicate readings was used. The coefficients of variation as a measure of the reproducibility of these measures were medial facet 2.6% and lateral facet 2.5%.

Data analysis. The change in patella cartilage volume and joint space narrowing at the different sites over the period of time was divided by time between MRI scans or radiographs to obtain an annual rate of change; i.e., the annual change in patellar cartilage volume (ml/yr) was calculated as the difference between the initial and followup patellar cartilage volumes divided by the time (in yrs) between images.

To assess whether relationships existed between the change in patella cartilage volume and joint space narrowing (measured by narrowest joint space or mid-joint space from the lateral radiographs, or the medial and lateral facets on the skyline radiographs), Spearman correlation coefficients were used. A p value < 0.05 (2 tailed) was regarded as statistically significant. All analyses were performed using the SPSS statistical package (version 10.0.5, SPSS, Chicago, IL, USA).

RESULTS

The demographic characteristics of study participants are presented in Table 1. Most had mild or moderate PF OA, with only 20 (20%) having grade 3 PF osteophytes and/or joint space narrowing on skyline radiographs and 8 (8%) on lateral PF views.

The average amount of patella cartilage lost per year was 133 ± 143 μm^3/yr (Table 2). When this was calculated as a percentage of the initial baseline cartilage, it represented an annual rate of loss of patella cartilage of 4.4 ± 4.4%. Measures of radiological progression of PF OA are presented in Table 2. The largest change in joint space over the study period was measured using narrowest joint space on the lateral PF radiographs.

There was a significant correlation between the measures of change in joint space narrowing as measured at the medial and lateral facet on the skyline radiographs and between the mid-point joint space and narrowest joint space as measured on the lateral PF radiographs (Table 3); i.e., between the measures of change in joint space narrowing when measured within the lateral and the skyline radiographs, but not in measures across the lateral and skyline radiographs (Table 3). Each of these radiographic assessments of change at the PF joint was compared to change in total patella cartilage volume (Table 3). There was a weak, but statistically significant association between the change in patella cartilage volume and the change in narrowest joint space on the lateral PF radiographs. There was no association between the change in patella cartilage volume and change in joint space width at the midpoint on the lateral patella radiographs or the change in joint space at either the medial or lateral facets on the skyline radiographs.

DISCUSSION

In our longitudinal study of 102 symptomatic patients with predominantly mild to moderate OA, we found a statistically significant association between change in narrowest joint space, as measured from the lateral PF radiographs, and change in patella cartilage volume. There was no asso-

Table 1. Characteristics of study population. Results are expressed as mean (SD). Moderate OA defined as ≥ grade 2 PF osteophyte or joint space narrowing.

	Total Population, n = 102
Age, yrs	63.8 (10.1)
Female, %	63
Height, cm	166.5 (8.6)
Weight, kg	79.7 (8.6)
BMI	28.7 (5.0)
Time between scans, yrs	1.9 (0.3)
No. (%) with moderate PF OA	47 (47%)

Table 2. Measurement of rate of change of patella cartilage volume and radiographic assessment of the PF joint over time. Results are expressed as mean (SD).

	Baseline	Followup	Difference	Annual Change
Patella cartilage volume, μm^3	3203 (1023)	2934 (962)	253 (261)	133 (143)
Lateral radiographs, mm				
Narrowest joint space	15.3 (6.3)	14.2 (5.9)	1.1 (5.5)	0.7 (2.6)
Midpatella joint space	20.3 (6.8)	19.9 (6.6)	0.4 (7.4)	0.2 (3.8)
Skyline radiographs, mm				
Minimum medial facet joint space	19.8 (6.9)	18.9 (6.4)	0.9 (6.5)	0.4 (3.9)
Minimum lateral facet joint space	17.7 (6.0)	17.4 (6.8)	0.3 (7.4)	0.2 (3.4)

Table 3. Correlation between the change in patella cartilage volume and radiographic assessment of the PF joint over time.

	MRI	Lateral Radiographs		Skyline Radiographs
	Patella Cartilage Volume	Narrowest Joint Space	Midpatella Joint Space	Minimum Medial Facet Joint Space
Lateral radiographs				
Narrowest joint space	0.22 p = 0.03	—	—	0.16 p = 0.12
Midpatella joint space	0.07 p = 0.50	0.60 p = 0.001	—	0.08 p = 0.44
Skyline radiographs				
Minimum medial facet joint space	0.01 p = 0.92	0.11 p = 0.27	0.05 p = 0.61	—
Minimum lateral facet joint space	0.03 p = 0.77	0.15 p = 0.15	0.05 p = 0.66	0.35 p < 0.001

ciation between the change in patella cartilage volume and joint space narrowing measured from the medial and lateral facets on the skyline radiographs or with change in joint space narrowing measured from the midpoint of the patella on lateral radiographs.

There is little information available on the rate of progression of PF OA or how it should be measured. Indeed, it is unclear which view of the PF joint, the lateral or skyline view of the knee, is a better measure of change. One study compared lateral and skyline views in the assessment of radiological progression of PF OA in 54 hospital-referred patients (108 knees), with knee OA followed over an average of 31 months[5]. The decrease in mean joint space was –0.5 mm (95% confidence interval, CI: –0.1 to –0.8) for the medial facets and –0.4 mm (95% CI –0.2 to –0.6) for the lateral facets. This was similar to that observed in our study. On the lateral view, the change in narrowest joint space was –0.2 mm (95% CI 0.1 to –0.5), which was somewhat less than the 0.7 mm reduction we observed. The reason for this is unknown. Our population was recruited from the community rather than being hospital-based. It is possible that differences in disease stage influence the rate of progression of disease.

No previous study has examined how radiological change at the PF joint relates to change in patella cartilage. This is important, given that radiographic assessment of joint space narrowing is being used as a surrogate measure of change in joint cartilage. In our study, only change in narrowest joint space, as measured on the lateral radiographs, was significantly associated with change in patella cartilage volume. Although this association was statistically significant, it was not very strong. This may in part be due to precision errors in the measurement techniques. However, these tended to be relatively low. The most likely reason for the low correlation is that joint space narrowing and cartilage volume do not measure exactly the same structures. Joint space narrowing as measured from radiographs only examines articular cartilage indirectly. Further, joint space narrowing is a unidimensional measurement of a 3-dimensional structure. Consequently it is not surprising that we found only a low correlation. However, more importantly, there was a statistically significant association with minimum joint space width rather than mid-joint space width, suggesting that this measure may most closely reflect what is happening at the PF joint. This is probably not surprising and may in part be due to the fact that joint space is a unidimensional assessment of joint cartilage, which is a 3-dimensional structure. However, despite this, a statistically significant correlation was observed with change in narrowest joint space and change in patella cartilage volume over 2 years.

In contrast, no such relationship was observed with measurement of change in joint space narrowing in the medial and lateral facets of the skyline radiographs. In support of this, a previous study has shown a poor correlation between skyline views and computed tomographic images in assessing the PF joint[14]. The bone edges seen on a skyline view are not necessarily opposing[6]. On a lateral view, however, the most posterior part of the patella and the intercondylar groove are represented by lines in the same vertical plane, unless significant subluxation has occurred. There is no method to account for subluxation when measuring joint space narrowing on radiographs, which presents a further potential of their limitation. In addition, it is important keep in mind that in our study we measured the whole patella cartilage volume. In contrast, the joint space narrowing measured from the skyline radiographs measures the medial and lateral facet joint spaces separately. This is also a potential problem in interpreting the results of the radiographic study comparing progression of PF OA based on lateral radiographs and the medial facet on skyline radiographs. It may be that a stronger relationship with skyline measurements would be seen if the lateral and medial components of patella cartilage were examined separately.

Measurement of cartilage volume is limited by the contrast between articular cartilage and the adjacent tissues. Our method has been validated against cadavers and has excellent reproducibility, with coefficients of variation of 2–3%[9,12]. To improve in-plane resolution, we use a matrix of 512 × 512 pixels, resulting in an in-plane resolution of 0.31 mm × 0.31 mm. In this study, we only measured the patella cartilage, as a measure of what is happening to joint cartilage in the PF joint. There are potential problems in using femoral cartilage since it contributes to 3 joints, the medial and lateral tibiofemoral joints and the PF joint. There is no simple, discrete boundary that allows anatomical definition of the component of the femoral cartilage that takes part in the PF joint in contrast to the other joints. For this reason, it is a very convenient option to use a simple, well-defined anatomical structure, such as patella cartilage, as a surrogate measure of what is happening at the PF joint. We have also shown that measurement of patella cartilage volume alone correlates with radiographic grade of joint space width and osteophytes at the PF joint (unpublished data).

In subjects with knee OA, patella cartilage volume was lost at about 4.4% per annum. Based on our data, a sample size of 70 in each arm of the study would be required to examine an intervention that reduces cartilage loss by 50% (power 80%, alpha error of 5%). This is similar to the number that would be required to show a comparable effect size at the tibiofemoral joint[15]. In contrast, given the wider variability in the change in joint space width if we were to use radiographs, the sample size would have to be about 800 for a similar effect size to be detected.

Our data suggest that minimum joint space narrowing measured on lateral PF radiographs correlates with patella cartilage loss. In contrast, measurement of the change in joint space narrowing in the midpoint of the patella on the lateral views or measurement of change in joint space at either the medial and lateral facets on skyline view did not correlate with change in patella cartilage volume. Larger studies are needed to determine the role of these different measures in assessing progression of PF OA.

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