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# Joint space width of the tibiofemoral and of the patellofemoral joint in chronic knee pain with or without radiographic osteoarthritis: a 2-year follow-up

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## Summary

*Objectives*: To assess the interval change of the minimal joint space width (MJS) in radiographs of the tibiofemoral (TF) joint and of the patellofemoral (PF) joint with a 2-year follow-up in middle-aged people with longstanding knee pain with or without radiographic osteoarthritis (OA) and to study the precision of the MJS measurements.

*Design*: In the format of a prospective study of early OA the signal knee in 55 people, 28 men and 27 women (aged 41–57 years, median 50), with chronic knee pain at inclusion was examined with a 2-year interval (median 25 months, range 21–30). The MJS of the TF joint was measured using a flexed PA view in weightbearing and the MJS of the PF joint using an axial view in standing.

*Results*: The MJS of the TF joint decreased medially by 0.056±0.44 mm (n.s.) and increased laterally by 0.080±0.51 mm (n.s.) during the time of observation. In knees with an MJS medially that was less or the same as compared with the lateral compartment, the MJS decreased by 0.14±0.38 mm ($p=0.038$) and in a subgroup of these knees, without osteophytes, the MJS decreased by 0.14±0.27 mm ($p=0.018$). The MJS of the PF joint decreased by 0.019 mm (n.s.) during the time of observation. The coefficient of variation for intra- and interobserver MJS measurements of the TF joint was 1.0 and 1.1% medially and 2.3 and 2.7% laterally, and for measurement error 6.9% medially and 4.8% laterally, respectively. The coefficient of variation for intra- and interobserver MJS measurements of the PF joint was 8.1 and 5.8% medially and 7.5 and 10.1% laterally and for the measurement error it was 8.1% medially and 8.5% laterally, respectively.

*Conclusions*: A statistically significant reduction of the MJS was only demonstrated in the medial compartment of the TF joint in those individuals who had an MJS in this compartment which was less or the same as compared with the lateral compartment as well as in a subgroup of these knees without osteophytes. The radiographic examinations and the MJS measurements were reproducible.


*Key words:* Osteoarthritis, Knee, Radiography, Progression.

## Introduction

Osteoarthritis (OA) is a multifactorial process affecting cartilage and subchondral bone. It is the most common articular disease, but much remains to be known about the cause, natural history, and progression of the disease[1].

Measurement of the minimum joint space width (MJS) is the primary outcome variable in studies of progression in the tibiofemoral (TF) and the patellofemoral (PF) OA[2]. For longitudinal studies of the MJS in TFOA, weightbearing radiographs in flexion are preferable as well as axial radiographs in PFOA. Longitudinal studies of TFOA with assessment of the MJS using this radiographic technique are few[3,4], as are the same type of studies of PFOA in using axial radiographs[5]. All these studies were performed in older age groups and to our knowledge no longitudinal studies of early knee OA including both the TF and the PF joints are available.

In an attempt to identify early signs of progress of knee OA, a prospective study on middle-aged people with chronic knee pain in southwest Sweden was initiated, 'the Spenshult cohort'[6]. The aims of the present study were to assess the MJS in a flexed weightbearing PA view of the TF joint and in a standing axial view of the PF joint, and further, to study the sensitivity of interval change with a 2-year follow-up in people with and without radiographic knee OA.

## Methods

SUBJECTS

To create a cohort of people with chronic knee pain at inclusion (duration >3 months) for prospective follow-up, an epidemiological survey of 2000 people aged 35–54 years in a rural area in southern Sweden, was performed, 'the Spenshult cohort'[6] (Fig 1). Chronic knee pain at inclusion was reported by 279 of 1853 people who completed the questionnaire and 204 of 279 consented to be examined

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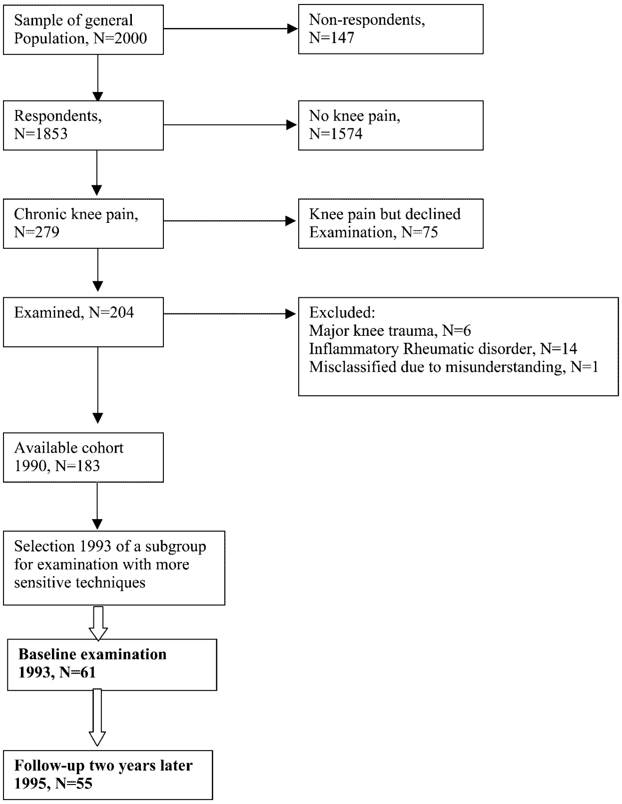


Fig. 1. The flow from sample of population at baseline to study cohort.

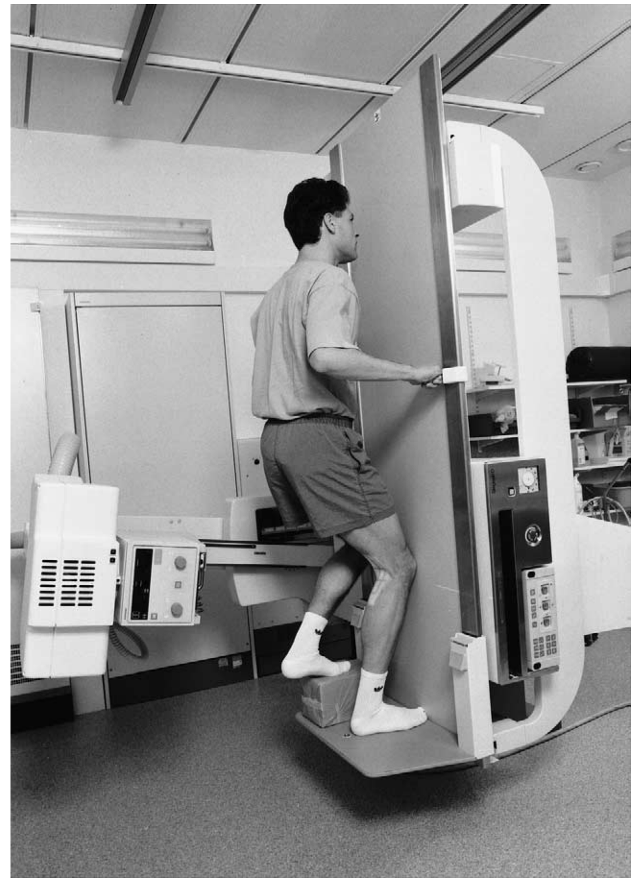

Fig. 2. The position for obtaining the flexed PA view of the TF joint (after Boegård *et al.*[8] with permission from Acta Radiol).

clinically, biochemically, and radiographically (the TF joint) at baseline in 1990–1991. After exclusion of individuals with chronic arthritides or previous severe knee trauma, 183 people with knee pain, with and without radiographic OA, remained for follow-up.

To study longitudinal changes in knee joints in individuals with chronic knee pain at inclusion with new and more sensitive techniques, a subgroup of 61 people (61/183) were chosen as a sample from the initial cohort excluding those with more severe radiographic OA of the TF joint (i.e. obliteration of the joint space or bone attrition). The baseline examination using these more sensitive techniques occurred 3 years after the initial examination of the cohort (see Fig. 1). All 61 subjects had at this time point, hereafter called the baseline study, a weightbearing PA radiograph of the TF joint of both knees. All subjects except for the initial two people also had an axial radiograph in standing of the PF joint of both knees.

At the examination of this subgroup 2 years later, hereafter called the follow-up study, all 61 people were offered the same radiographic examinations of the signal knee (the most painful at inclusion) and 55 accepted. Three out of these 55 people had undergone a high tibial osteotomy and were excluded from the TF part of the study, as was one patient who had a TF radiograph of inferior quality at the baseline study. In this study, the medial TF joint space was totally obliterated in one patient and measurements of this compartment were excluded as well as the measurements of the lateral compartment in one patient due to pronounced translation and in another patient with considerable posttraumatic deformity of the lateral tibial condyle, leaving 50 medial TF compartments and 49 lateral TF compartments in 51 people for comparison. Two out of the 55 people who accepted to be examined at the follow-up study had no axial radiographs of the PF joint at the baseline study, leaving 53 PF joints for comparison. There were 28 men (aged 41–57, median 50) and 27 women (aged 42–57 years, median 50). The median interval between the radiographic studies was 25 months (range 21–30).

RADIOGRAPHIC EXAMINATION

The TF radiograph was obtained in the PA view in a weightbearing position with the knee flexed. Fluoroscopic guidance was used on a tiltable table with a spot film device and with a tube angulation possibility[7] (Fig. 2). The radiograph was obtained with almost the whole weight on the examined leg and with the patella and the big toe of the examined leg touching the table. The knee was flexed by 30–50° and the medial aspect of the foot was parallel to the central X-ray beam and the beam was adjusted to be tangential to the anterior and posterior aspects of the medial tibial plateau. The film-focus distance was 115 cm.

At the baseline study, the intra- and interobserver agreement of the MJS measurements of the medial and lateral compartments of the TF joints was studied in the left knee of 21 consecutive people. The reproducibility of the flexed PA knee radiographs and the error of the MJS measurements in the medial and the lateral TF joints were evaluated

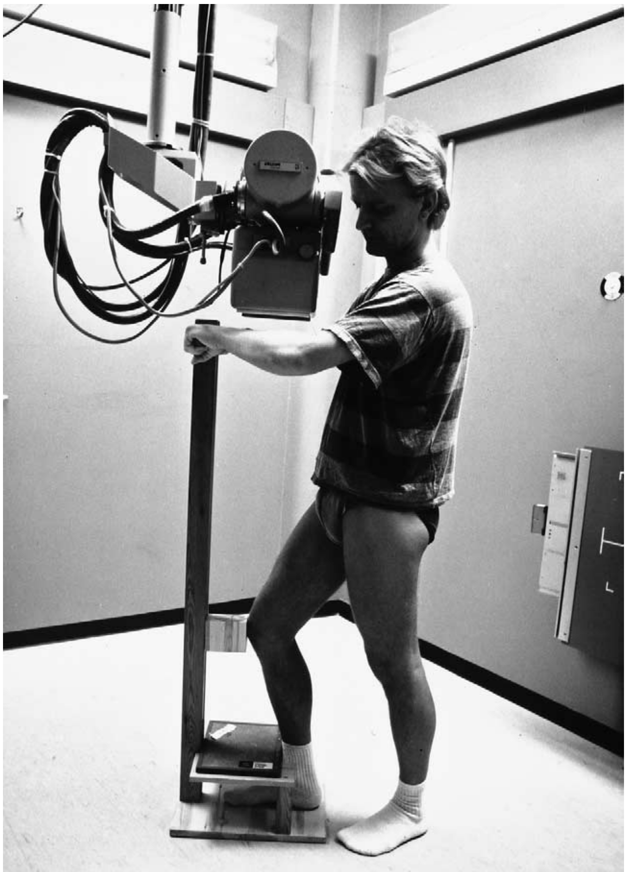

Fig. 3. The position for obtaining the axial view of the PF joint (after Boegård *et al.*[10] with permission from Acta Radiol).

in 26 knees from 13 consecutive individuals examined twice by the same radiology technician with an interval of 5–7 h.

The mean magnification factor in the flexed PA knee view has previously been reported to be 1.18 with a 95% confidence interval 1.17–1.20[7].

The axial view of the PF joint was obtained with the patient standing and with a vertical beam according to Ahlbäck[9], using the technique previously described[10] (Fig. 3). The aim was to get a tangential view of the dorsal aspect of the patella. The beam or the angulation of the femur or of the tibia was adjusted blindly if this was not achieved. The flexion of the knee joint was in most examinations 40–60° and the film-focus distance 150 cm.

In the baseline study, the intra- and interobserver agreement of the MJS measurements of the medial and lateral compartments of the PF joints was studied in the signal knee of all people. In the same study, the reproducibility of the axial radiographs and the error of the MJS measurements of the PF joint were evaluated in 28 knees from 14 consecutive individuals examined twice by the same radiology technician with an interval of 5–7 h. The results of these studies have previously been reported[10]. The $\kappa$ values for intra- and interobserver agreement of the MJS width measurements of the PF joints were 0.91 and 0.94 medially and 0.91 and 0.84 laterally, respectively. The weighted $\kappa$ values were 0.97 and 0.93 for the same measurements, and the measurement error was 8.1% medially and 8.5% laterally, respectively. The MJS measurements of the PF joint, which were used to calculate the intra- and interobserver variations in our study from 1998[10], were revaluated to be expressed as the within-subjects coefficient of variation (WSCV) in percent[11].

The mean magnification factor in the axial view of the PF joint has previously been reported to be 1.28 with a 95% confidence interval 1.25–1.34[10].

The examinations of the TF and PF joints were performed late in the afternoon, between 4.30 and 6.00 p.m. In the ongoing study we did not correct for the magnification in the radiographs of the TF and the PF joints.

### METHODS OF MEASUREMENT

The reader (T.B.) was blind regarding the time sequence of the examinations (the baseline study and the follow-up study) and the name and the age of the patient. Furthermore, the time sequence was randomly chosen in the examinations and the radiographs of the TF and PF joints were read on separate occasions. Both radiographs of the TF joint (from the baseline study and from the follow-up study) in each patient were available for assessment to enable the reader to identify and use the same anatomical landmarks for the MJS measurements in each study according to a standardized procedure. The same procedures were used when evaluating the PF joints. The bony margins used for measuring the interbone distance in our study have been described by Buckland-Wright[12]. The MJS measurements of the TF joint were taken in the horizontal part of the joint and not between the tibial spines and the femoral notch.

With a 2-week interval, one of the radiographs of the TF joint in each patient was evaluated twice by one radiologist (T.B.) and on one occasion by another radiologist (O.R.) in order to calculate intra- and interobserver agreement. The radiographs were assessed without knowledge of the name or the age of the people and the reader was also unaware of the previous MJS measurements in the same patient.

The MJS of the TF joint was measured using a ×7 (Peak, Japan) magnifying lens fitted with a 10 mm graticule with a 0.1 mm division on the plain film across the narrowest part of both the medial and lateral TF compartments. The MJS of the PF joint was measured in millimeter and half-millimeter with a standard millimeter-graded plastic ruler as the blurring caused by fairly large magnification factor made it impossible to use a caliper metered to the nearest 0.1 mm[10]. The measurement was taken on the plain film across the narrowest joint space, corresponding to the central 3/4 of the articular surfaces of the femoral trochlea[10].

### KNEE PAIN

Before inclusion in the Spenshult cohort, the individuals were asked through a postal questionnaire ‘Have you had pain in any of your knees practically daily for the last 3 months?’. In the baseline study described in this article, all individuals completed a brief, standardized questionnaire about current knee pain, knee operations, and major knee trauma of the signal knee. They were also asked about changes of the problems of the signal knee since inclusion in the study 3 years earlier and about intercurrent illness.

STATISTICAL ANALYSES

The difference in the MJS between the examinations at the baseline study and at the follow-up study was estimated and tested with a paired *t*-test. *p*-Values <0.05 were considered statistically significant. The intra- and interobserver variations, and the measurement error were examined in terms of WSCV[11].

## Results

In the 51 people with TF radiographs available for comparison, osteophytes of grade 1 according to Altman *et al*.[13] were found in 20 TF joints of the signal knee at the baseline study, osteophytes of grade 2 or 3 in four joints and in 27 joints no osteophytes were detected.

In the 53 people with PF radiographs available for comparison, osteophytes of grade 1 according to Altman *et al*.[13] were found in 33 PF joints of the signal knee at the baseline study, osteophytes of grade 2 or 3 in five joints, and in 15 joints no osteophytes were detected.

At the baseline study, the knee pain in 34 people was unchanged or worse and in 21 people the pain was less or appeared only irregularly as compared with the findings at the time of the inclusion in the study in 1990–1991.

Tables I and II summarize the changes of the MJS of the TF and PF joints during the 2 years of observation.

Joint space narrowing of the TF joint (MJS <3.0 mm)[7] was found medially in five people and laterally in one patient at the baseline study. Two years later another two people had narrowing of the medial TF compartment. During the 2 years of observation the mean MJS decreased (n.s.) in the medial TF compartment and increased (n.s.) in the lateral TF compartment. The change over time was statistically significant medially in a subset of 41 knees with an MJS less or the same in the medial compartment as compared with the lateral compartment at the baseline study ($p<0.038$) and medially in a subgroup of these knees, which included 24 knees without peripheral osteophytes ($p<0.018$). The intraobserver variation in measuring the MJS of the TF joint was 1.0% (2 SD=0.09 mm) medially and 1.1% (2 SD=0.13 mm) laterally. The corresponding figures for the interobserver variation were 2.3% (2 SD=0.21 mm) and 2.7% (2 SD=0.32 mm). The measurement error of the MJS was 6.9% for the medial TF compartment and 4.8% for the lateral compartment.

Joint space narrowing (MJS <5 mm)[9] of the PF joint was found in 17 joints at the baseline study. PF joints with obliteration of the joint space or with bone attrition were not found. At the follow-up study, another patient had narrowing of the PF joint. During the 2 years of observation, the mean MJS of PF joints decreased by 0.019 mm (n.s.). No correlation was found on a knee level between the change in the TF joint and in the PF joint. The intra- and interobserver variations of MJS measurements of the PF joint were 8.1 (2 SD=1.04 mm) and 5.8% (2 SD=0.93 mm) medially and 7.5 (2 SD=0.71 mm) and 10.1% (2 SD=1.20 mm) laterally. The measurement error was 8.1% medially and 8.5% laterally.

## Discussion

The Spenshult cohort[6], consisting of middle-aged men and women with chronic knee pain at inclusion, was established for a prospective follow-up primarily to identify factors and signs, which can influence or predict the development of the OA disorder. The subgroup examined in this study was chosen accordingly from the initial cohort.

As early as 1968 Ahlbäck[9] found that radiographs in weightbearing position were more accurate than examination in a supine position to assess joint space width in knee OA. Observations during arthroscopy[14,15] and in MR imaging[7] have revealed that cartilage lesions in the medial femoral condyle are predominantly located in a more dorsal position. This portion of the medial femoral condyle is in contact with the medial tibial plateau in flexion of the knee and corresponds to the power position used for walking up stairs, cycling etc. This finding has been confirmed by several radiographic studies on knee OA[4,14–19].

In our study of the TF joint, a flexed PA view in weightbearing has been used. Even if the flexion of the knee is not fixed and is estimated to between 30 and 50° we want to point out that our procedure in other ways is highly standardized with the patella touching the table and thus keeping the magnification factor constant and low. The examination is performed with a constant rotation of the leg with the medial aspect of the foot parallel to the central X-ray beam and with the big toe touching the table. We also use fluoroscopy to ensure that the posterior and anterior aspects of the medial tibial plateau are tangential with the central X-ray beam (a high degree of alignment). The anatomical landmarks used measuring the interbone distance are clearly defined keeping the intraobserver and interobserver variations low. The intraobserver variation was 1.0% medially and 1.1% laterally and the interobserver variation was 2.3% medially and 2.7% laterally. All factors make the reproducibility good and the measurement error was 6.9% medially and 4.8% laterally.

In general, in our study, during the 2 years of observation, the mean MJS of the TF joint seemed to decrease in the medial compartment (n.s.) and to increase in the lateral compartment (n.s.). The mean difference was small, only 0.056 mm in the medial compartment and 0.080 mm in the lateral compartment. This can be compared with a mean difference of 0.20 mm (3.01–2.81 mm) (n.s.) in the medial compartment during 18 months of observation using PA microfocal radiography in weightbearing and semiflexion in 66 knees with osteophytes and subchondral sclerosis in 33 people with a mean age of 59 years[3]. Our results can also be compared with a mean difference of 0.40 mm ($p<0.05$) in the medial compartment during a 1-year observation using flexed PA radiographs in weightbearing (the Lyon schuss view) in 19 knees with medial OA in 10 people with a mean age of 64 years[4].

These two studies use radiographic protocols with knee flexion, which we consider superior to assess the TF joint. This justifies a comparison even if the protocols are different in several respects. Buckland-Wright *et al*.[3] used macroradiography in the semiflexed PA view with the knee flexed between 1 and 20° while Piperno *et al*.[4] used standard radiography in the Lyon schuss PA view with the knee flexed 28–35°. In both studies, the MJS measurements were computer based while we used manual measurements in standard radiography of the knee in a flexed PA view with the flexion estimated to between 30 and 50°. The coefficient of variation for the MJS in the medial and the lateral compartments in repeated studies using microfocal radiography[20] was 1.2 and 3.8%, respectively. The corresponding value for the medial compartment, using a conventional radiographic technique[4] was 3.5%, while the precision of repeated examinations in our study was slightly inferior, 6.9% in the medial TF compartment and 4.8% in the lateral TF compartment. In our study, the

Table I

*Measurements and differences, with a 2-year interval, of the MJS in the medial and the lateral compartments of the TF joint of the signal knee in 51 people using weightbearing posteroanterior radiographs in flexion*

| | Mean MJS (mm) at baseline (SD) | Mean MJS (mm) at follow-up (SD) | Mean difference in MJS (mm) between baseline and follow-up | 95% confidence interval of the difference (lower and upper) | *p*-Value |
|---|---|---|---|---|---|
| MJS all knees; medial (*n*=50) | 4.35 (1.24) | 4.29 (1.44) | 0.056 | −0.070 and 0.182 | 0.37 |
| MJS all knees; lateral (*n*=49) | 5.91 (1.38) | 5.99 (1.37) | −0.080 | −0.226 and 0.067 | 0.28 |
| MJS; medial ≤ lateral (*n*=42) | 4.10 (1.15) | 3.97 (1.26) | 0.13 | 0.008 and 0.245 | 0.038 |
| MJS; lateral < medial (*n*=8) | 4.84 (1.05) | 5.08 (1.42) | −0.24 | −0.684 and 0.209 | 0.25 |
| MJS (>4 mm); medial ≤ lateral (*n*=23) | 4.80 (0.70) | 4.71 (0.84) | 0.083 | −0.046 and 0.211 | 0.20 |
| MJS ≤4 mm; medial ≤ lateral (*n*=19) | 3.26 (0.94) | 3.08 (1.10) | 0.18 | −0.046 and 0.404 | 0.11 |
| MJS; medial ≤ lateral (*n*=18) with osteophytes | 3.77 (1.49) | 3.66 (1.71) | 0.11 | −0.140 and 0.362 | 0.36 |
| MJS; medial ≤ lateral (*n*=24); no osteophytes | 4.35 (0.66) | 4.21 (0.72) | 0.14 | 0.026 and 0.249 | 0.018 |

Table II
*Measurements and differences, with a 2-year interval, of the MJS of the PF joint of the signal knee in 53 people using axial radiographs in standing*

| | Mean MJS (mm) at baseline (SD) | Mean MJS (mm) at follow-up (SD) | Mean difference in MJS (mm) between baseline and follow-up | 95% confidence interval of the difference (lower and upper) | *p*-Value |
|---|---|---|---|---|---|
| MJS all knees (*n*=53) | 5.65 (1.46) | 5.63 (1.42) | 0.019 | −0.16 and 0.20 | 0.84 |
| MJS ≤5 mm (*n*=17) | 3.91 (0.75) | 3.97 (0.86) | −0.059 | −0.37 and 0.25 | 0.70 |
| MJS >5 mm (*n*=36) | 6.47 (0.87) | 6.42 (0.82) | 0.056 | −0.18 and 0.29 | 0.63 |

precision of repeated MJS measurements by a single observer was 1.0% medially and 1.1% laterally. The corresponding values given for microfocal radiography are 0.6 and 3.6%, respectively[20], and for the conventional radiographic technique used by Piperno *et al*.[4] 5.1% medially.

The difference in the reduction of the MJS of the medial TF compartment between the studies seems to be mainly a matter of patient selection. The age of the people and the grade of OA are of great importance for the outcome. In these respects, our people were much younger and only one half of them had radiographic TFOA, which were in most cases mild and the other half of our people had no radiographic sign of OA at all.

A statistically significant decrease of the MJS of the medial TF compartment was found in knees with an MJS less or the same in this compartment as in the lateral compartment at the baseline study and also in a subgroup of these knees without osteophytes. The mean difference was to 0.13 mm and 0.14 mm in these groups respectively. The finding in knees without osteophytes is interesting as these knees without radiographic signs of OA in individuals with chronic knee pain may represent a pre-osteoarthritic stage.

A limitation of our radiographic technique is the possible variation in repositioning the joint in exactly the same flexion at repeat examinations. This variation can be attributed to TF joint laxity, associated articular cartilage loss, and reduction in ligament tension with joint flexion. This may explain the somewhat inferior reproducibility of our MJS measurements on repeated examinations, as compared with other studies using almost the same technique[3,4].

Longitudinal studies of the progression of OA of the PF joints using the axial view of the joint are few[5]. In the study by Lanyon *et al*.[5] they could show a significant reduction of the width of both the medial and the lateral PF joint space over a mean time of 31 months in 108 knees in 54 people with a mean age of 71 years. We were not able to show this. The reasons are several. On average, our people were 20 years younger and the OA disorder in this age group is less pronounced. We obtained the axial view of the PF joint in standing while Lanyon *et al*.[5] used a technique described by Laurin *et al*.[21] with the patient sitting down and the X-ray beam more or less horizontal. No study has compared the different techniques. The radiographic features of OA in the PF joint are irregular and sometimes difficult to interpret. However, with our methodology we have previously shown that there is a high degree of correlation between JSN (<5 mm) and the presence of significant cartilage defects as seen on MR imaging[10]. Blurring caused by a fairly large magnification factor made it impossible in our own study to use a caliper metered to the nearest 0.1 mm and therefore we used millimeter-graded standard plastic ruler with less accuracy. Despite this, the intraobserver agreement in both studies was very good, >0.80.

We have formerly described that there were only minor changes of progress seen on MR imaging over time in this patient cohort[22]. These findings as well as the findings of the present study seem to reflect a slower and more unpredictable change over a 2-year period than has been seen in other follow-up studies[23].

To conclude, with weightbearing flexed PA radiographs of the TF joint, which are used in daily clinical routines, it is possible to detect a statistically significant change in the MJS of the medial TF compartment over a 2-year period in a subgroup of middle-aged people with chronic knee pain at inclusion. However, the changes of the MJS are small in this age group, which should be taken into account when choosing people and evaluation methods for prospective studies of symptomatic knee OA, including clinical trials. No statistically significant change of the MJS of the PF joint was found during the same time period.

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