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Can standing knee radiographs predict chondral lesions in young- and middle-aged population?

Akin Uzumcugil · Senol Bekmez · Defne Kaya · Ahmet Ozgur Atay · Mahmut Nedim Doral

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Abstract
Purpose The aim of the study is to investigate the correlation between arthroscopic findings and joint space width on the standing knee radiographs at various flexion degrees in the young- and middle-aged patients with complaints of knee pain.
Methods Middle-aged patients with complaint of knee pain ongoing more than 6 months and failure in conservative treatment methods were included. Weight-bearing full extension, 30 and 45° of flexion radiographs were obtained. Joint space width was calculated on radiograms. Arthroscopy was performed to evaluate the chondral pathologies. Correlation analysis was performed.
Results Fourty-three patients (18 female, 25 male) with a mean age of 44.6 (20–63) were included. Mean joint space width was 4.87 mm ± 1.45 (2–10) mm in medial and 5.43 mm ± 1.47 (1–9) in lateral on standing extension radiographs. In 30° flexion radiographs, mean joint space width was 4.33 mm ± 1.25 (1.5–7.5) in medial and 5.36 mm ± 1.69 (1–9) in lateral. In 45° flexion radiographs, medial joint space was 4.28 mm ± 1.59 (2–9) in medial and 5.15 mm ± 1.59 (1.5–9) in lateral. In arthroscopic evaluation, one knee had grade 1 (2.3 %), three knees had grade 2 (7 %), nine knees had grade 3 (20.9 %), and twelve knees had grade 4 (27.9 %) lesions in the medial compartment. In the lateral compartment, two knees had grade 3 (4.7 %) and one knee had grade 4 lesion (2.3 %). Radiological data did not correlate with the arthroscopic findings.
Conclusion Standing knee radiographs do not correlate with the arthroscopic findings in the middle-aged population with chondral lesions in knee joint.
Level of evidence Case series with no comparison group, Level IV.

Keywords Weight-bearing · Knee · Radiographs · Cartilage · Lesion · Young

A. Uzumcugil (✉) · S. Bekmez · A. O. Atay · M. N. Doral
Department of Orthopedics and Traumatology, Faculty of Medicine, Hacettepe University, Ankara, Turkey
e-mail: akinu@hacettepe.edu.tr

D. Kaya
Department of Sports Medicine, Faculty of Medicine, Hacettepe University, Ankara, Turkey

Introduction

Several radiological investigations, such as conventional radiography, computerized tomography (CT) and magnetic resonance imaging (MRI), have been defined to figure out the severity of knee osteoarthritis. Among all, MRI is the best method to visualize the articular cartilage and to evaluate the cartilage thickness and damage [8, 15]. However, due to its technical advantages and cost effectiveness, conventional radiography is still the most widely preferred method to assess the severity of the osteoarthritis [27].

Narrowing at the joint line on knee radiographs is a well-defined reliable parameter for the diagnosis of knee osteoarthritis. In 1960s, Ahlbäck described the standing extension view for the evaluation of knee osteoarthritis in a study of 181 knees [1]. However, further studies pointed some restrictions in standing extension views for the evaluation of the severity of the chondral damage. Obtaining a perfect alignment with the roentgen beam was difficult in extension views because of the anatomic orientation of medial tibial plateau [5, 8]. Therefore, more recent studies focused on finding out the most reasonable degree of femorotibial joint flexion to demonstrate better

the severity of cartilage destruction. Rosenberg et al. [27] reported that the weight-bearing radiographs in 45° of flexion provide better visualization of the narrowing and more accurate measurement than the standing weight-bearing anteroposterior radiographs. Following several studies also concluded that flexion views at various degrees were more reproducible and accurate than the standing extension views [5, 21, 31].

Although standing knee flexion radiography is accepted as a standard method of evaluating degenerative pathologies of the knee, there is still little information about their arthroscopic validation especially in patients with mild cartilage lesions. Additionally, most of the studies concerning the correlation between radiographic and arthroscopic findings are based on older age populations. [14, 16, 27]. A weight-bearing knee radiography protocol can be a cost-effective and feasible screening method for the mild chondral pathologies of the knee joint in young population and also can reduce the requirement of MRI as an expensive and time-consuming diagnostic test. The aim of the study was to compare arthroscopic findings with narrowing of the knee joint space width on standing knee radiography at different flexion degrees in the young- and middle-aged patients with chondral pathology.

Materials and methods

Forty-three patients with an average age of 44.6 (20–63) were admitted to our outpatient clinic between the years 2001 and 2002. The selection criterion was the complaint of knee pain ongoing for more than 6 months without responding to the non-surgical treatment.

Radiographs

All radiographs were obtained with the patients standing on both legs. Roentgen beam-cassette distance was 100 cm. The flexion angle was measured with a manual goniometer during radiographic imaging by the same technician for all patients.

Standing anteroposterior knee radiographs at full extension were taken with a horizontal roentgen beam; 30° flexion posteroanterior radiographs were also taken with a horizontal roentgen beam and with feet externally rotated at about 15° [6]. Posteroanterior knee radiographs at 45° of flexion were obtained with a roentgen beam angled 10° downwards [25].

Joint space width

After all radiographs obtained, they had been evaluated for joint space narrowing by two independent observers. Medial and lateral compartments were divided into three sub-compartments. Joint space width was measured at the narrowest part of those 6 sub-compartments for all knees and recorded in millimetres (Fig. 1). In cases of any disagreements between the observers, a third independent observer re-evaluated the radiographs. Ten standing extension views, ten 30° flexion views and ten 45° flexion views those were selected randomly were re-evaluated by one observer.

Arthroscopic evaluation

Twenty-four right knees and 19 left knees undergone arthroscopic surgery by the same surgeon. General anaesthesia or spinal anaesthesia was performed depending on the patients' medical condition and requests. Standard knee arthroscopy in medial and lateral portals was performed. All three compartments were evaluated for chondral, meniscal and ligamentous pathologies (Fig. 2). Outerbridge system [23] was used for grading the chondral lesions. Lateral retinacular release was performed in the presence of lateral retinacular tightness. Debridement, microfracture or laser chondroplasty was the treatment options, depending on the grade of the chondral lesions. Loose bodies were extracted. Irreparable meniscal tears were undergone partial meniscectomy. Repairable peripheral meniscal tears were sutured with all inside technique.

Statistical analysis

Data were summarized as mean ± standard deviation (SD). Spearman's correlation analysis was used to compare radiological findings, age and arthroscopic findings. The results were analysed using a statistical software package, SPSS 11.5, Chicago, IL, USA. For all analysis, $p < 0.05$ was considered as statistically significant.

Results

The narrowest zones in femorotibial joint spaces determined in radiographs are summarized in Tables 1, 2. Joint space width measurements in the narrowest zones are summarized in Table 3.

Arthroscopic findings were summarized in Table 4. Microfracture was done in eight knees with grade 3–4 chondral lesions. All grade 3–4 lesions were medial femoral condylar lesions except one patient with lesions in both medial and lateral femoral condyles. Twenty-seven concomitant meniscal tears were diagnosed and treated properly. Arthroscopic synovectomy was performed in one knee with synovitis. Loose bodies were extracted in two patients.

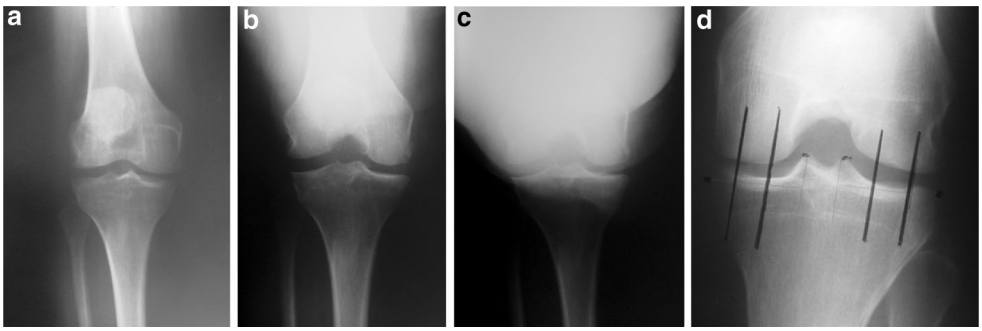

Fig. 1 Standing weight-bearing knee radiography of a patient in 0, 30 and 45° of flexion (**a**, **b**, **c**). The radiographic measurement of joint width in six compartments (**d**)

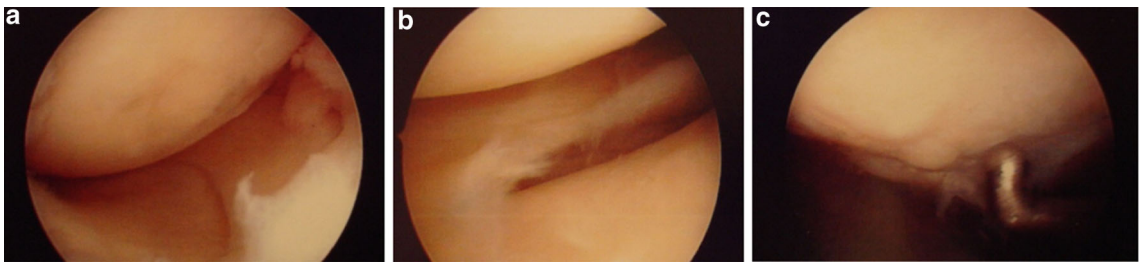

Fig. 2 Arthroscopic evaluation of medial (**a**), lateral (**b**) and patellofemoral (**c**) compartments

Table 1 Distribution of the radiological narrowest zones of the medial compartment at different flexion degrees

Compartments with knee flexion degrees	Number and percentage of knees narrowest at Zone 1	Number and percentage of knees narrowest at Zone 2	Number and percentage of knees narrowest at Zone 3
Medial 0°	5	28	10
	11.6 %	65.1 %	23.3 %
Medial 30°	3	35	5
	7 %	81.4 %	11.6 %
Medial 45°	5	35	3
	11.6 %	81.4 %	7 %

Table 2 Distribution of the radiological narrowest zones of the lateral compartment at different flexion degrees

Compartments with knee flexion degrees	Number and percentage of knees narrowest at Zone 1	Number and percentage of knees narrowest at Zone 2	Number and percentage of knees narrowest at Zone 3
Lateral 0°	6	32	5
	14 %	74.4 %	11.6 %
Lateral 30°	7	22	14
	8.1 %	54.1 %	37.8 %
Lateral 45°	10	25	8
	23.3 %	58.1 %	18.6 %

Statistical analysis revealed that radiological data did not correlate with the arthroscopic findings. Medial joint space narrowing and age had significant strong correlation between female patients ($r = 0.77$, $p < 0.001$) and moderate correlation between all patients ($r = 0.53$, $p < 0.01$).

Table 3 Joint space width (in millimetres)

Compartments with knee flexion degrees	Mean joint space width (mm)	SD (mm)	Range (mm)
Medial joint space extension	4.9	1.5	2–10
Medial joint space 30°	4.3	1.3	1.5–7.5
Medial joint space 45°	4.3	1.6	2–9
Lateral joint space extension	5.4	1.5	1–9
Lateral joint space 30°	5.4	1.7	1–9
Lateral joint space 45°	5.2	1.6	1.5–9

SD standard deviation

Discussion

The most important finding of the present study is the exhibition of the uselessness of the standing knee radiographs at various flexion degrees in prediction of the chondral pathologies in young- and middle-aged population.

Table 4 Arthroscopic evaluation

Compartments	Outerbridge 0	Outerbridge I	Outerbridge II	Outerbridge III	Outerbridge IV
Medial compartment	18	1	3	9	12
	42 %	2 %	7 %	21 %	28 %
Lateral compartment	40	0	0	2	1
	93 %	0 %	0 %	5 %	2 %

Outerbridge grade distributions for femorotibial joint surfaces

Globally accepted radiographic finding of the knee osteoarthritis is the joint space narrowing in the anteroposterior standing radiographic view. Fairbank et al. [9] described the radiological findings in knee joint after total meniscectomy as the formation of osteophytes at the margins, flattening of the femoral condyle and narrowing of the cartilage space. Several radiographic grading systems had been developed for determining the severity of knee osteoarthritis, including Kellgren–Lawrence, Brandt and Ahlbäck scales [1, 12, 12]. Those scales are based on the narrowing of the joint space in standing knee radiographs. Following studies emphasized that distance between the opposing weight-bearing subchondral cortical surfaces of femoral condyles and tibial plateaus, also named as minimum joint space width, is compatible with the articular cartilage thickness [5, 22].

Correlation between the radiological grading systems and arthroscopic findings of femorotibial osteoarthritis were investigated [2, 10, 14, 16, 29]. All of these three grading systems were found to be sensitive for the detection of early osteoarthritic changes. Those scales were equally effective in detection and estimation of the severity of osteoarthritis in the knee joint. However, there was a weak correlation with the actual degree of articular cartilage degeneration especially in earlier stages of osteoarthritis [14]. The painful periods of the disease were attributed to alter the minimum joint space width as a result of muscle spasms [20]. In a study of 161 patients with chronic knee pain, Fife et al. [10] established that arthroscopic examination was grossly normal in 30 per cent of patients who had significant joint space narrowing at standing anteroposterior view. They concluded that radiographic evidence of joint space narrowing in the femorotibial compartment did not permit a confident prediction of the status of an articular cartilage. In this study, we also found a poor correlation between standing extension views and arthroscopic findings in middle-aged patients, especially in terms of detecting the severity of cartilage lesions, as compatible with the literature.

Later studies established the knee flexion to enhance the radiological demonstration of the loss of articular cartilage in mild lesions [18, 26]. Because radiography of the partially flexed knee had been attributed to demonstrate the area of the femoral condyle mostly at risk, Maquet et al. [17] concluded that, major contact stresses in the femorotibial articulation occur as the knee in about 28° of flexion. The most reliable degree of knee flexion to evaluate the cartilage integrity is controversial. Takahashi et al. [28] concluded that measurements of the medial joint space width and intermargin distance are smallest at 15° of knee flexion among various degrees of knee flexion. They suggested that radiographs should be obtained at this angle in order to demonstrate the extent of osteoarthritis accurately. Messieh et al. [20] compared the extension radiographies with the standing tunnel views of 64 patients. They reported that 10 knees displayed severe degeneration in 30° flexed posteroanterior standing view in whom standing extension views suggested as normal. Rosenberg et al. [27] described the 45° flexed posteroanterior standing view and correlated the radiographic narrowing with the intraoperative findings at fifty-five patients. They also stated that 45° flexed posteroanterior view was more accurate, more sensitive and more specific than the standing extension weight-bearing anteroposterior radiographs. There are also several other studies supporting that the moderate osteoarthritis could be more accurately detected in the fixed flexion views than that of extended standing views. In contrast, standing radiographs in full extension and 45° of flexion were found to be useless for the detection of mild chondral damage [21, 30]. In this study, standing extension, 30° and 45° of flexion views were taken into account in middle-aged population.

Another point of issue is the weight bearing on one or both legs in the radiological evaluation. Boegard et al. [4] established that the assessment of joint space narrowing in the posteroanterior view of the knee joint in weight-bearing examinations should be performed with equal weight on both legs. Because standing on one leg caused to widening of the medial joint space. However, standing only on the examined leg might be an option in cases of suspected narrowing in the lateral compartment. In this study, standing knee radiographs were taken with weight bearing on both legs depending on this opinion.

However, the knee flexion radiography protocols have poor inter- and intraobserver reliability. Besides, lateral compartment disease can be difficult to assess as the positioning is often very poor and patient positioning schemes generally focus on obtaining ideal images in the medial compartment. Another problem in flexion radiographic protocols is the absence of standardization of positioning to obtain osteoarthritis progression. Mazzuca et al. [19] indicated that joint space narrowing could not

been detected in serial views performed 14 months later, due to the variations in muscle strength, knee pain and structural deformities. Alternatively, several authors suggest that fluoroscopy-assisted semi-flexed knee views offer a precise evaluation of joint space width [7]. In a study conducted by Boegard et al., in the middle-aged individuals, fluoroscopy-assisted semi-flexed posteroanterior view was performed in those whom had previously diagnosed cartilage defects detected by MRI. They concluded that minimal joint space of 3 mm was a limit in diagnosing joint space narrowing in knees with previously detected cartilage defects in MRI [3]. Nonetheless, such a procedure is time-consuming, expensive and subjects the patients to a larger radiation exposure. Eventually, Peterfy et al. [24] established that fixed flexion views were more feasible than fluoroscopy-assisted methods and can provide reproducible joint space width measurements. We preferred fixed flexion methods rather than fluoroscopically assisted ones because of the easy applicability and reproducibility.

In this study, we compared radiographic joint space narrowing with gold standard arthroscopic findings. In our series of 43 patients with knee pain, our data showed that plain radiographs with standing in full extension anteroposterior and in 30° and 45° posteroanterior positions were inadequate for the assessment of articular cartilage in the earlier stages of chondral damage in middle-aged population. The most common localization of the chondral lesion was the medial femoral condyle as compatible with the literature [11].

The importance of this study arises from concerning a special age interval. Also, radiographs in various degrees of flexion were evaluated in the same study. Nevertheless, there are certain limitations of this study. One of them is the lack of randomization of the study population. The study population was selected from symptomatic patients whom did not respond conservative methods, not from a middle-aged cohort. As another limitation, magnetic resonance imaging as an actual method to evaluate cartilage lesions was not evaluated in this study.

Finally, standing knee radiography protocols at various angles of femorotibial joint flexion are not reliable for clinical prediction of the severity of cartilage pathology in the young- and middle-aged patients. Consequently, it is not logical to use weight-bearing knee radiography at any angles of flexion as a screening method in clinical practice to detect chondral pathologies in young- and middle-aged population with knee pain.

Conclusion

The joint width narrowing on standing radiography protocols of the knee joint with various degrees of flexion in young- and middle-aged patients does not correlate with the severity of chondral lesions diagnosed by arthroscopic examination. However, there is a moderate correlation between the age of patient and medial joint width narrowing on standing radiographs.

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