

## Systematic Review

Sensitivity of Standing Radiographs to Detect Knee Arthritis:  
A Systematic Review of Level I Studies

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**Purpose:** The purpose of this study was to perform a systematic review of the available literature to define the level of quality evidence for determining the sensitivity and specificity of different radiographic views in detecting knee osteoarthritis and to determine the impact of different grading systems on the ability to detect knee osteoarthritis. **Methods:** A systematic review of the literature was conducted to identify studies that evaluated the standing anteroposterior (AP) and 45° posteroanterior (PA) views for tibiofemoral and patellofemoral arthritis and those comparing the use of the Kellgren-Lawrence versus the joint space narrowing (JSN) radiographic grading systems using arthroscopy as the gold standard. A comprehensive search of PubMed, Scopus, CINAHL, the Cochrane Database, [ClinicalTrials.gov](http://ClinicalTrials.gov), and EMBASE was performed using the keywords “osteoarthritis,” “knee,” “x-ray,” “sensitivity,” and “arthroscopy.” **Results:** Six studies were included in the evaluation. The 45° flexion PA view showed a higher sensitivity than the standing AP view for detecting severe arthritis involving either the medial or lateral tibiofemoral compartment. There was no difference in the specificities for the 2 views. The direct comparison of the Kellgren-Lawrence and the JSN radiographic grading systems found no clinical difference between the 2 systems regarding the sensitivities, although the specificity was greater for the JSN system. **Conclusions:** The ability to detect knee osteoarthritis continues to be difficult without using advanced imaging. However, as an inexpensive screening tool, the 45° flexion PA view is more sensitive than the standing AP view to detect severe tibiofemoral osteoarthritis. When evaluating the radiograph for severe osteoarthritis using either the Kellgren-Lawrence or JSN grading system, there is no clinical difference in the sensitivity between the 2 methods; however, the JSN may be more specific for ruling in severe osteoarthritis in the medial compartment. **Level of Evidence:** Level I, systematic review of Level I studies.

Osteoarthritis is a chronic and potentially debilitating condition. For the young and the elderly, osteoarthritis can lead to decreased physical activity, predisposing them to cardiovascular disease, weight gain, and diabetes. For older adults in particular, there is decreased independence. As a result, practitioners need to be able to reliably detect knee osteoarthritis. Screening tools have been used to identify structural signs of knee osteoarthritis. Numerous studies<sup>1-15</sup> have examined a range of imaging modalities from radiography to magnetic resonance imaging as screening tools for osteoarthritis. These

studies found that the ability to detect structural changes of the articular cartilage in the knee consistent with osteoarthritis is difficult. Standing or weight-bearing radiographs, rather than supine radiographs, have been the preferred imaging method to detect joint space narrowing, which is indicative of structural damage to the articular cartilage of the knee and osteoarthritis.<sup>1,10,16-20</sup> The ability of knee radiographs to detect osteoarthritis is important because studies have found that the presence of knee articular cartilage damage is associated with a poor clinical outcome after knee arthroscopy.<sup>21-24</sup> These

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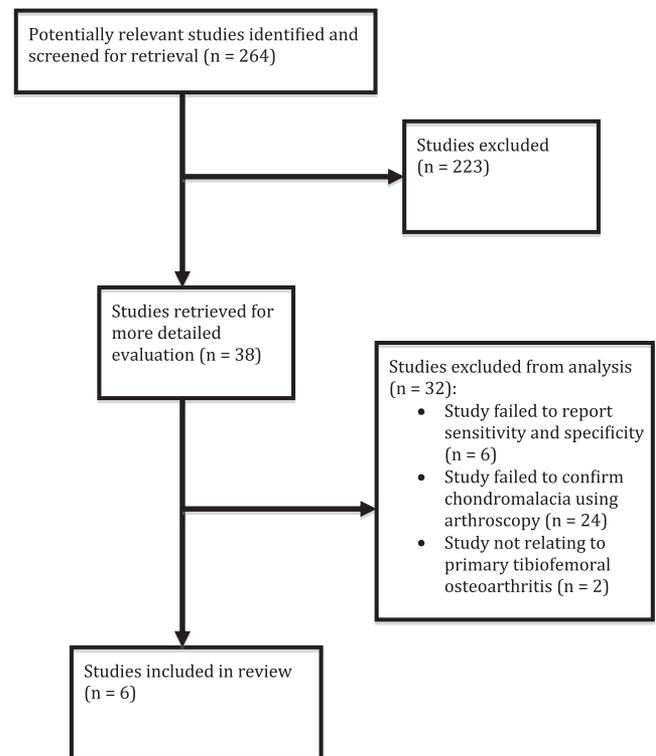
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structural changes are seen as joint space narrowing on standing radiographs and are characterized and graded at arthroscopy as to degrees of chondromalacia.

Debate has arisen over which weight-bearing radiographic view is best able to detect knee osteoarthritis and which radiographic view best detects this cartilage damage seen at arthroscopy. The standing anteroposterior (AP) and weight-bearing posteroanterior (PA) views have been used with mixed results regarding their sensitivity to detect knee osteoarthritis.<sup>18,25</sup> The grading system used to indicate the severity of the osteoarthritis also affects the sensitivity of the radiograph to detect knee osteoarthritis. To resolve this debate over which radiographic view and grading system to use, we performed a systematic review to (1) determine if there is a clinical difference in the sensitivity or specificity between the standing AP view and the weight-bearing flexion PA view for detecting knee osteoarthritis using arthroscopic confirmation of chondromalacia grade and (2) determine if there is a difference between using the grading system of Kellgren-Lawrence versus joint space narrowing (JSN) for detecting knee osteoarthritis.

## Methods

An electronic search of PubMed, Scopus, CINAHL, the Cochrane Central Register of Controlled Trials, and [ClinicalTrials.gov](http://ClinicalTrials.gov) was performed for articles published between January 1823 and July 2014, and a search of EMBASE was performed for the years 1947 through 2013 on July 21, 2014. Search strategies were created to include the MEDLINE keywords "osteoarthritis," "knee," "x-ray," "arthroscopy," and "sensitivity"; the EMBASE keywords "osteoarthritis," "knee," "x-ray," and "sensitivity"; the Web of Science keywords "osteoarthritis," "knee," "x-ray," and "sensitivity"; and the Cochrane Database keywords "osteoarthritis," "knee," and "x-ray." In addition, a hand search of the *Journal of Bone and Joint Surgery* (American and British volumes), *Clinical Orthopaedics and Related Research*, *American Journal of Sports Medicine*, the *Journal of Arthroplasty*, and *Arthroscopy* was performed for the past 6 months of publication. Case reports and reviews were excluded using filters constructed in a similar manner. To exclude animals, the human filter for PubMed was used as recommended in the "Cochrane Handbook for Systematic Reviews of Interventions," and similar filters were used for the other databases searched.<sup>26</sup> Search results were entered into EndNote to remove duplicate studies. The flowchart in [Figure 1](#) shows the review process from the original search to those included in the final study. The initial searches yielded 264 eligible studies. Review of the abstracts of the identified studies was performed to include only studies in the English language, those limited to humans, those identifying primary osteoarthritis, those using either the standing AP or the 45° PA



**Figure 1.** Flow diagram of the method of article selection for study inclusion.

radiographic view, those reporting the sensitivity and specificity of each radiographic view with a minimum radiographic view of one compartment examined, and those confirming chondromalacia grade using the gold standard of arthroscopy. This initial review identified 35 abstracts and articles. The references of these identified abstracts and articles were also searched for studies meeting inclusion criteria, yielding 3 additional studies for a total of 38 articles. A secondary review identified our final set of 6 studies, excluding 32 studies. Exclusion criteria specified those studies failing to report sensitivity and specificity,<sup>27-32</sup> those failing to confirm chondromalacia using arthroscopy,<sup>13,14,33-54</sup> and those not relating to primary tibiofemoral osteoarthritis.<sup>55,56</sup> Six studies remained.<sup>8,10,18,25,57,58</sup> After identification of appropriate studies, data extraction was independently performed using a standardized format.<sup>59</sup> The data were compiled in tabular form ([Tables 1](#) and [2](#)). Quality appraisal and interpretation of the results were then performed to reach our conclusions.

## Results

### Demographics and Study Design

[Table 1](#) represents the 6 studies examining the ability of radiographic views to detect osteoarthritis of the knee. All 6 studies used arthroscopy as the gold standard for determining the presence of structural change to articular cartilage (graded as degree of

**Table 1.** Study Population, Demographics, and Summary of Methods and Criteria Used for Grading of Chondropathy Using Radiography and Arthroscopy

Reference	N	Average Age, (+ SD or Range)	% Women	Level of Evidence	Radiographic View	Criteria for Radiograph Positive for OA	Radiographic Control	Osteoarthritis/ Chondromalacia Grading System Used at Arthroscopy	Type of Practice	Symptom Duration*	Fulfill ACR Criteria† for OA?	Percent of Severe OA at Arthroscopy‡
Wada et al., 1998 <sup>57</sup>	190	65.2 (41-80)	85%	I	Standing AP	Kellgren and Lawrence: definite osteophytes and possible JSN; JSN > 50%	No	Koshino and Machida	NR	Chronic	Yes	Medial, 79%
Dervin, et al., 2001 <sup>8</sup>	152	60.5 (+ 8.5)	51%	I	3-ft AP and 45° PA	JSN > 2 mm	No	SFA	General outpatient orthopaedic clinic	Chronic	Yes	Medial, 57% Lateral, 13%
Rosenberg et al., 1988 <sup>18</sup>	55	NR (19-70)	NR	I	Standing AP and 45° PA	JSN > 2 mm	Contralateral knee compartment	Outerbridge	Knee and sports medicine clinic	Chronic	NR	Medial, 51% Lateral, 18%
Lysholm et al., 1987 <sup>58</sup>	63	50.7 (+ 11.8)	13%	I	Standing AP	Ahlback <sup>1</sup> JSN (amount not indicated)	No	Outerbridge	General outpatient orthopaedic clinic	Chronic	NR	Medial, 38%
Wright, et al., 2006 <sup>25</sup>	349	38 (12-85)	NR	I	Standing AP and 45° PA	JSN > 2 mm	Contralateral knee compartment	Outerbridge	Sports medicine clinic	Acute	No	Medial, 10%
Fife et al., 1991 <sup>10</sup>	161	36.4 (+ 12.9)	17%	I	Standing AP	JSN > 25%	Contralateral knee compartment	Outerbridge	Sports medicine clinic	Chronic	NR	Medial, 6% Lateral, 3%

NOTE. The 6 studies examining the ability of the radiographs to detect osteoarthritis of the knee. All 6 studies used arthroscopy as the gold standard to determine articular cartilage damage. Study design regarding radiographic view, criteria for defining severe radiographic arthritis, and type of control used to define osteoarthritis are listed.

ACR, American College of Rheumatology; AP, anteroposterior; JSN, joint space narrowing; NR, not reported; OA, osteoarthritis; PA, posteroanterior; SD, standard deviation; SFA, Société Française d'Arthroscopie (French Society of Arthroscopy).

\*Acute is defined as less than 3 months' duration and chronic is defined as more than 3 months' duration.

†ACR criteria: Must meet 3 of 6: age > 50 yr, stiffness < 30 min, crepitus, bony tenderness, bony enlargement, and no palpable warmth.

‡Severe OA: Outerbridge grade III or IV, SFA grade III, Koshino and Machino grade III.

**Table 2.** Diagnostic Accuracy of Radiography for Detecting Chondromalacia Confirmed at Arthroscopy

Study	Sensitivity, %	Specificity, %	Accuracy, %	Positive Predictive Value, %	Negative Predictive Value, %
Wada et al. <sup>57</sup>					
Standing AP (grades III/IV)					
JSN, medial	83	96*	81	99	44
Kellgren and Lawrence, medial	95	59*	89	93	68
Dervin et al. <sup>8</sup>					
3-ft AP (grades III/IV)					
Medial	73	82	78	64	86
Lateral	42	99	93	83	94
45° PA (grades III/IV)					
Medial	78	76	77	60	88
Lateral	83	96	95	72	98
Rosenberg et al. <sup>18</sup>					
Standing AP (grades III/IV)					
Medial	25*	96	60*	88	55
Lateral	30*	96	84*	60	86
45° PA (grades III/IV)					
Medial	86*	100	93*	100	87
Lateral	80*	100	96*	100	96
Lysholm et al. <sup>58</sup>					
Standing AP (grades III/IV)					
Medial	57	89	71	87	63
Wright et al. <sup>25</sup>					
Standing AP (grades II/III/IV)					
Medial	3	98	58	57	59
Lateral	11*	92	73	31	77
45° PA (grades II/III/IV)					
Medial	5	98	60	87	60
Lateral	2†	95	73	14	76
Standing AP (grades III/IV)					
Medial	3	98	88	14	90
Lateral	16	92	86	17	92
45° PA (grades III/IV)					
Medial	6	98	88	25	90
Lateral	6	96	88	14	91
Fife et al. <sup>10</sup>					
Standing AP (grades II/III/IV)					
Medial	71	60	63	36	87
Lateral	38	91	83	41	89
Standing AP (grades III/IV)					
Medial	75	61	64	36	89
Lateral	38	90	83	36	91

NOTE. Sensitivity, specificity, accuracy, positive predictive value, and negative predictive value for each of the included studies is presented. Also shown is the comparison of these values for the Kellgren-Lawrence and JSN scales, as shown by Wada et al.<sup>57</sup>

AP, anteroposterior; JSN, joint space narrowing; PA, posteroanterior.

\* $P < .01$ .

† $P < .008$ .

chondromalacia) of the knee. The grading system, the severity of chondromalacia at arthroscopy, the criteria for classifying knee osteoarthritis, and the control used for grading the degree of arthritis were included.<sup>27,60,61</sup> The type of orthopaedic practice in which each study was performed was also included in this table. In 3 of the 6 studies, the average age was older than 50 years (Dervin et al.,<sup>8</sup> Wada et al.,<sup>57</sup> and Lysholm et al.<sup>58</sup> classifications). The study by Rosenberg et al.<sup>18</sup> failed to report the average age of the patients, but the range was 19 to 70 years. Two of the 6 studies had a population with an average age younger than 40 years.<sup>10,25</sup>

There was not a predominance of one sex among the 6 studies. Five of the 6 studies examined a patient population that had chronic symptom duration defined as symptoms greater than 3 months.<sup>8,10,18,57,58</sup>

Categorization of severe of osteoarthritis (by chondromalacia grade) was determined using Outerbridge<sup>62</sup> grades III and IV, Société Française d'Arthroscopie (SFA)<sup>63</sup> grade III or greater, and Koshino and Machino<sup>64</sup> grade III or greater. Study design regarding the radiographic view, the criteria for defining severe osteoarthritis seen on radiographs, and the type of control used to define knee osteoarthritis is listed in Table 1.

## Radiographic Outcomes

All 6 studies examined the medial compartment of the knee. The sensitivity of the standing AP radiograph to detect significant medial compartment arthritis ranged from 3% to 95%. For the 45° flexion PA view, the sensitivity ranged from 6% to 86%. Three studies<sup>8,18,25</sup> directly compared the standing AP view versus the 45° flexion PA view for the medial compartment. All 3 studies found the 45° flexion PA view to be more sensitive at detecting severe osteoarthritis, but only one study<sup>18</sup> found a statistically significant difference of 61% between the 2 views ( $P < .01$ ) (Table 2).

For the lateral compartment of the knee, 4 studies reported on the sensitivity of the standing AP knee radiographs to detect severe osteoarthritis, which ranged from 16% to 42% (Table 2).<sup>8,10,18,25</sup> For the 45° flexion PA view, 3 studies reported the sensitivity to range from 6% to 83%. For the 3 studies that directly compared the standing AP view to the 45° flexion PA view for detecting severe lateral compartment arthritis, most found the 45° PA view to be more sensitive at detecting severe arthritis (Table 2).

One study examined using 2 different radiographic grading systems to detect osteoarthritis.<sup>57</sup> The study found that the Kellgren-Lawrence system was more sensitive for the severe osteoarthritis in the medial compartment, with 95% sensitivity versus 83% for the JSN classification, but this was not statistically or clinically significant. The JSN classification was more specific for the medial compartment, with 96% specificity versus 59% for the Kellgren-Lawrence system, which was statistically significant ( $P < .01$ ) (Table 2).

## Discussion

Knee osteoarthritis is one of the most common types of arthritis, and the incidence is continuing to rise as the life expectancy of the general population increases.<sup>65</sup> Patients presenting with knee pain can be challenging to diagnose and treat. With overlap between knee osteoarthritis, referred pain from the hip or spine, and complex disorders such as fibromyalgia or complex regional pain syndrome, the correct diagnosis for a patient can be difficult to determine. Radiographs are often used to screen patients for knee osteoarthritis. Therefore, this systematic review was performed to examine the ability of knee radiographs to detect osteoarthritis regarding (1) which radiographic views to obtain and (2) which radiographic grading system to use.

For patients with mild osteoarthritis, being able to detect the amount of osteoarthritis with an inexpensive screening tool such as radiography has proved ineffective in this study and others.<sup>25</sup> Because the results after knee arthroscopy versus medical therapy for symptomatic knee osteoarthritis have shown no additional benefit for arthroscopic surgery,<sup>66</sup> the ability to detect chondromalacia is becoming more important. In

addition, recent treatment guidelines from the American Academy of Orthopaedic Surgeons for knee osteoarthritis have changed, such as their withdrawal of support for using hyaluronic acid injection for symptomatic knee osteoarthritis.<sup>67</sup> Thus, the ability to accurately diagnose knee osteoarthritis and provide evidence-based therapy is important. For patients with mild osteoarthritis (Kellgren-Lawrence grade II), more advanced imaging studies such as magnetic resonance imaging are likely needed to help guide treatment decision making because the sensitivity of radiography is low.<sup>25</sup> The ability of radiography to detect arthritis is better in patients with more advanced osteoarthritis (grade III or IV). The standing 45° PA view proved to be more sensitive at detecting knee arthritis than the standing AP view. Although the study by Wright et al.<sup>25</sup> had low sensitivity for detecting severe knee osteoarthritis, this study was in a younger patient population (< 40 years of age). The remaining studies showed higher sensitivities, especially for the 45° PA view of the medial (Dervin et al.,<sup>8</sup> 78% and Rosenberg et al.,<sup>18</sup> 86%) and lateral (Dervin et al.,<sup>8</sup> 83% and Rosenberg et al.,<sup>18</sup> 80%) compartments. The standing AP view also showed good results for the medial compartment (sensitivity range, 25% to 95%) in patients older than 40 years; however, the results were less successful for the lateral compartment (sensitivity range, 30% to 42%). Thus, for detecting severe knee osteoarthritis of either the medial or lateral compartment, obtaining the 45° PA view will be able to detect advanced osteoarthritis more often.

Being able to accurately interpret radiographs and determine the level of osteoarthritis is important. Previous studies have addressed the variability in interpreting knee radiographs for osteoarthritis. Vilalta et al.<sup>68</sup> determined the agreement among reviewers to be 50% when using the Kellgren-Lawrence grading system. The Kellgren-Lawrence grading system uses 4 parameters for grading radiographs: presence of osteophytes, JSN, degree of sclerosis, and bony deformity. Schiphof et al.<sup>69</sup> reported on the variability of the description of the Kellgren-Lawrence grading system used to define the grade of knee osteoarthritis. As others have shown, osteophytosis does not always correlate with severe osteoarthritis but rather with aging.<sup>70-72</sup> This review failed to find a statistically or clinically relevant difference in the ability to detect severe knee osteoarthritis when using either the JSN or Kellgren-Lawrence grading system. However, the JSN grading system was more specific for detecting advanced osteoarthritis in the medial compartment.

## Limitations

This systematic review is limited by a number of factors. The exclusion criteria used and the design and

quality of the included studies potentially limited the overall number of studies examined. Finding quality Level I studies that directly correlate radiographic findings with arthroscopic findings is difficult. With few articles reporting on the radiographic and arthroscopic findings, and the variable means of reporting these findings, summarizing the results can be difficult. With the exception of the study by Wright et al.,<sup>25</sup> the study populations were relatively small. Post hoc power analysis even for the 2 larger studies comparing the different radiographic views (Dervin et al.<sup>8</sup> and Wright et al.<sup>25</sup>) found these to be underpowered at 17.2% and 27%, respectively. Limiting the review to only those studies that qualified as Level I evidence may have also excluded quality studies, including those that examined the patellofemoral joint. An exhaustive literature search for studies involving the patellofemoral joint with arthroscopic confirmation was performed, resulting in only one high-quality study.<sup>55</sup> One difficulty inherent in radiographic examination of the patellofemoral joint is that it requires technically difficult axial radiographs such as the Merchant or Sunrise views. These views require obtaining a tangential view of the patellofemoral joint, which changes with varying degrees of flexion. In addition, the importance of radiographic patellofemoral arthritis may be called into question when treating patients because it is often left untreated at the time of medial compartment arthroplasty.<sup>73</sup> As such, we believe that analysis of the ability of radiographs to detect patellofemoral arthritis falls outside the scope of this review.

## Conclusions

The diagnosis and treatment of patients with knee pain can be challenging. The use of knee radiographs to help diagnose and guide treatment has been practiced for years. Standing knee radiographs, especially the 45° flexion PA view, are sensitive for detecting severe osteoarthritis of the tibiofemoral joint. Using the amount of JSN as a guide for the amount of osteoarthritis can help to both rule in and rule out the presence of severe osteoarthritis. Further studies are needed to help determine the optimal diagnostic tests to evaluate osteoarthritis of the patellofemoral joint and mild osteoarthritis involving the tibiofemoral joint.

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