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Association of hip pain with radiographic evidence of hip osteoarthritis: diagnostic test study

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ABSTRACT

STUDY QUESTION

Is there concordance between hip pain and radiographic hip osteoarthritis?

METHODS

In this diagnostic test study, pelvic radiographs were assessed for hip osteoarthritis in two cohorts: the Framingham Osteoarthritis Study (community of Framingham, Massachusetts) and the Osteoarthritis Initiative (a multicenter longitudinal cohort study of osteoarthritis in the United States). Using visual representation of the hip joint, participants reported whether they had hip pain on most days and the location of the pain: anterior, groin, lateral, buttocks, or low back. In the Framingham study, participants with hip pain were also examined for hip pain with internal rotation. The authors analysed the agreement between radiographic hip osteoarthritis and hip pain, and for those with hip pain suggestive of hip osteoarthritis they calculated the sensitivity, specificity, positive predictive value, and negative predictive value of radiographs as the diagnostic test.

STUDY ANSWER AND LIMITATIONS

In the Framingham study (n=946), only 15.6% of hips in patients with frequent hip pain showed radiographic evidence of hip osteoarthritis, and 20.7% of hips with radiographic hip osteoarthritis were frequently painful. The sensitivity of radiographic hip osteoarthritis for hip pain localised to the groin was 36.7%, specificity 90.5%, positive predictive value 6.0%, and negative predictive value 98.9%. Results did not differ much for

hip pain at other locations or for painful internal rotation. In the Osteoarthritis Initiative study (n=4366), only 9.1% of hips in patients with frequent pain showed radiographic hip osteoarthritis, and 23.8% of hips with radiographic hip osteoarthritis were frequently painful. The sensitivity of definite radiographic hip osteoarthritis for hip pain localised to the groin was 16.5%, specificity 94.0%, positive predictive value 7.1%, and negative predictive value 97.6%. Results also did not differ much for hip pain at other locations.

WHAT THIS STUDY ADDS

Hip pain was not present in many hips with radiographic osteoarthritis, and many hips with pain did not show radiographic hip osteoarthritis. Most older participants with a high suspicion for clinical hip osteoarthritis (groin or anterior pain and/or painful internal rotation) did not have radiographic hip osteoarthritis, suggesting that in many cases, hip osteoarthritis might be missed if diagnosticians relied solely on hip radiographs.

FUNDING, COMPETING INTERESTS, DATA SHARING

See the full paper on thebmj.com for funding. The authors have no competing interests. Additional data are available from bevochan@bu.edu.

Introduction

Osteoarthritis of the hip is a major source of morbidity, causing pain, gait abnormalities, and functional impairments. According to the Centers for Disease Control and Prevention, more than 332 000 total hip replacements are performed each year in the United States, mostly to treat osteoarthritis. In the urban and suburban community of Framingham, Massachusetts, the age standardized prevalence of radiographic evidence of hip osteoarthritis was 19.6% (from 2002-05), but the prevalence of symptomatic hip osteoarthritis was only 4.2%.¹

Hip pain is often the main symptom of hip osteoarthritis that triggers diagnostic evaluation and treatment. To make the diagnosis in people with hip pain, radiography is usually done, and those with pain and radiographic evidence of osteoarthritis are characterized as having hip osteoarthritis.² Though it is well known that radiographic osteoarthritis is often a late finding in those with knee osteoarthritis and that the concordance between knee pain and radiographic osteoarthritis is poor, less is known about the concordance between hip pain and radiographic hip osteoarthritis^{3,4}; this has been assessed by only a few studies.⁵⁻¹⁰ If people with hip osteoarthritis do not have radiographic evidence of the disease, many may not receive a diagnosis and therefore adequate

WHAT IS ALREADY KNOWN ON THIS TOPIC

Hip osteoarthritis is a major source of morbidity, causing pain, gait abnormalities, and functional impairments

The population of over 60s has more than doubled in the past 30 years in the US, and the cost of osteoarthritis and its morbidities continues to exponentially increase; in the US the estimated yearly cost of osteoarthritis is about \$185.5bn

A hip radiograph is usually obtained in people with hip pain to diagnosis hip osteoarthritis, and those with pain and radiographic evidence of osteoarthritis are characterized as having hip osteoarthritis

WHAT THIS STUDY ADDS

In two large epidemiological studies, hip pain was not present in many hips with radiographic evidence of osteoarthritis, and many people with painful hips did not have radiographic evidence of hip osteoarthritis

Most older people highly suspected of having clinical hip osteoarthritis (groin or anterior pain and/or painful internal rotation present) did not have radiographic hip osteoarthritis

Diagnosticians may miss many older people with hip osteoarthritis if they rely on radiographic evidence for diagnosis

treatment. Both the 2012 American College of Rheumatology and the 2014 Osteoarthritis Research Society guidelines for treatment of hip osteoarthritis recommend a combination of drug and non-pharmacological treatments. For example, they recommend appropriate injections in the correct location (hip joint), which would not be considered if the diagnosis were missed. Furthermore, targeted and specific rehabilitation strategies are recommended but differ depending on whether the patient has hip pain from osteoarthritis or another source. Guidelines recommend non-steroidal anti-inflammatory drugs for hip osteoarthritis, but there are no definitive treatment guidelines on these for hip bursitis, another common cause of hip pain.

Pain in the hip region is related to many causes, and many people with such pain do not have arthritis. However, the combination of pain in the groin associated with limited internal rotation or pain with internal rotation identifies those with hip arthritis and are components of the classification criteria for osteoarthritis.¹¹

We examined the concordance between hip pain and radiographic evidence of osteoarthritis and the diagnostic test performance of the radiograph in those with suspected clinical hip osteoarthritis. We evaluated data from two cohort studies where the evaluation of hip pain and radiographic diagnosis of hip osteoarthritis differed slightly.

Methods

The Framingham Osteoarthritis Study

A community based study of osteoarthritis was carried out in Framingham, Massachusetts in 2002-05. Participants were recruited from the Framingham community irrespective of symptoms, and every participant had radiographs. Recruitment has been described previously.¹² To be included participants had to be ambulatory (use of assistive devices such as canes and walkers was allowed) and have no plans to move away from the area for at least five years. Exclusion criteria were a history of bilateral total knee replacement, rheumatoid arthritis (or other forms of inflammatory arthritis), dementia, terminal cancer, or contraindications to magnetic resonance imaging (MRI). For our study, we included participants aged 50 years and older.

For the assessment of symptoms, participants filled out a questionnaire on the presence and frequency of joint symptoms. Using a homunculus in which each hip joint was depicted as a large circle in the groin, we asked participants whether they had hip pain on most days in that region. We defined those who answered yes as having frequent hip pain. If participants had frequent hip pain, we then asked about the location of the pain: groin, front of leg (anterior), outside the leg (lateral), low back, or buttocks. A standardized hip examination was carried out in those who reported frequent hip pain. They were asked about pain during passive internal rotation and palpation over the greater trochanteric region.

Hip images were obtained from a standing long limb film in the anteroposterior plane. The methods for

ascertaining radiographic hip osteoarthritis are described elsewhere.¹ We defined radiographic hip osteoarthritis as a Kellgren-Lawrence grade of 2 or more (definite joint space narrowing in either superolateral or superomedial sites of the hip joint plus a definite osteophyte). An experienced musculoskeletal radiologist (AG) and a rheumatologist (CK) graded the joint space narrowing and size of osteophytes in accordance with the Osteoarthritis Research Society International (OARSI) atlas.¹³ We have previously published data on the interobserver and intraobserver agreement for radiograph readings.¹

The Osteoarthritis Initiative

The Osteoarthritis Initiative is a multicenter longitudinal cohort study of osteoarthritis, which recruited 4796 people aged 45-79 during 2003-05 at four centers: Columbus, OH; Providence, RI; Baltimore, MD; and Pittsburgh, PA. The researchers initially recruited participants if they had or were at risk for knee osteoarthritis. Every participant underwent hip imaging. A description of the recruitment process is available (www.oai.ucsf.edu). As with the Framingham Osteoarthritis Study, inclusion criteria required participants to be ambulatory (use of assistive devices such as canes and walkers was allowed) with no plans to move away from the area for at least three years. People were excluded if they had a history of bilateral total knee replacement, bilateral bone-on-bone knee osteoarthritis, rheumatoid arthritis, contraindications to MRI, or comorbidities that might interfere with the ability to participate in a study for four years.

The ascertainment of hip pain in the Osteoarthritis Initiative differed slightly from that of the Framingham Osteoarthritis Study. In the Osteoarthritis Initiative, participants were shown a visual representation of the hip region, indicating the usual locations of osteoarthritis related pain,^{5,14} and they were asked whether they had pain, aching, or stiffness in the hip on most days of a month during the past year.¹⁵ Those who answered yes were considered to have frequent hip pain and asked to indicate on the diagram where the pain occurred: groin, front of leg (anterior), outside of leg (lateral), low back, or buttocks. Each hip was evaluated separately.

In the Osteoarthritis Initiative, participants underwent standard anteroposterior pelvic radiography while weight bearing with their feet internally rotated using a V shaped foot angulation frame. Two musculoskeletal radiologists (TML, PMJ) and a rheumatologist (NEL) assessed the radiographs for individual radiographic features of hip osteoarthritis using the OARSI atlas.¹³ Baseline radiographs of 4761 participants were screened for the presence of any hip osteophytes or joint space narrowing. Those without either finding were categorized as having a negative screen result, and a second reader viewed the radiograph for confirmation. If the second reader confirmed a negative screening result the radiographs were not evaluated further. Two readers independently assessed radiographs with a positive result and scored all radiographic features of

hip osteoarthritis using the OARSI atlas. At least two of three readers adjudicated disagreements between readers by consensus for the presence of any superolateral or superomedial joint space narrowing, femoral or acetabular osteophytes, cysts, sclerosis, or deformity of the femoral head.

We defined definite femoral and acetabular osteophytes and superolateral and superomedial joint space narrowing as grade 2 or more. Hips were classified as showing definite radiographic hip osteoarthritis based on the presence of any of the following: a modified Croft grade of 2 or more (≥ 2 definite osteophytes; definite joint space narrowing; sclerosis, cysts, or deformity); joint space narrowing plus grade 1 or more femoral osteophytes or grade 2 or more acetabular osteophytes; grade 2 or more femoral osteophytes regardless of other features; and superolateral joint space narrowing grade 2 or more or superomedial joint space narrowing grade 3 or more, regardless of other features. Hips were classified as showing possible radiographic hip osteoarthritis when other individual or combinations of indefinite individual radiographic features were present (for example, grade 1 osteophytes and/or grade 1 joint space narrowing), otherwise they were considered “normal.”^{16 17} Test-retest reliability of the reading method was evaluated in a random sample of 189 participants, the radiographs of whom were reread blindly by two readers with adjudication of disagreements. Reliability was generally good for medial and lateral joint space narrowing (weighted κ 0.72 to 0.77); superior and inferior femoral osteophytes (0.70 to 0.81); acetabular osteophytes (0.51 to 0.64); cysts, sclerosis, or deformity (0.53 to 0.55); the three level summary classification (0.72); and presence or absence of definite radiographic hip osteoarthritis (κ 0.77). Two readers blindly assessed the radiographs of 70 participants with negative results for radiographic hip osteoarthritis for individual radiographic features, with adjudication of disagreements. The specificity of screening for the absence of definite radiographic hip osteoarthritis was 99%, and the estimated sensitivity of screening for definite radiographic hip osteoarthritis was 93%.

Statistical analysis

To obtain sensitivity, specificity, and positive and negative predictive values of radiographic hip osteoarthritis for clinical symptoms of hip osteoarthritis for both cohorts, we used SAS for statistical analysis. All of these variables were joint specific and we included both hips for each participant.

To determine the presence of joint symptoms we constructed simple Venn diagrams (see supplementary figures) to show the overlap of frequent hip pain and a positive radiographic finding for hip osteoarthritis because frequent hip pain does not necessarily represent hip osteoarthritis.

To determine the frequency of joint symptoms, we used hip pain localized to the groin or anteriorly as the gold standard for detecting hip osteoarthritis; hip pain in these locations is far more likely to represent true hip joint pain (and with patients with inflammatory

arthritis excluded) and therefore to identify those with hip osteoarthritis. In addition, in Framingham we examined participants for pain during internal rotation. If they reported hip pain, we also characterized that as hip joint pain and treated it as the gold standard for detecting hip osteoarthritis. In this instance, we used the radiographs as a diagnostic test and the clinical gold standard method as the diagnosis. Therefore we calculated sensitivity as the percentage of participants with the clinical gold standard of hip osteoarthritis with positive radiographic results, and specificity as the percentage of participants with hips without the clinical gold standard of hip osteoarthritis with negative radiographic results. The positive predictive value is the proportion of hips with radiographic hip osteoarthritis that had a clinical gold standard for hip osteoarthritis. Lastly, we calculated the negative predictive value as the proportion of hips without radiographic hip osteoarthritis that had no clinical gold standard. In addition to using hip pain with anterior thigh or groin pain as the gold standard, we also present diagnostic test findings for frequent hip pain as the gold standard even though hip pain is not a good proxy for hip osteoarthritis.

We excluded replacement hips from analysis. For both cohorts, analysis was done to examine hip pain localized to other regions (lower back, buttocks, or lateral), but these locations had similar poor agreements with positive radiographic findings.

Patient involvement

No patients were involved in setting the research question or the outcome measures, nor were they involved in developing plans for recruitment, design, or implementation of the study. No patients were asked to advise on interpretation or writing up of results. There are no plans to disseminate the results of the research to study participants or the relevant patient community.

Results

The Framingham Osteoarthritis Study

The prevalence of radiographic hip osteoarthritis was 13.6% (95% confidence interval 10.7% to 16.5%) for women and 24.7% (20.6% to 28.7%) for men.¹ Pain in either hip was reported by 24.7% (21.2% to 28.6%) of women and 14.7% (11.4% to 18.0%) of men.¹ For this analysis, radiographs from 1850 hips in 946 participants were evaluated. Table 1 shows the characteristics of the cohort and hip based prevalence of pain by location.

Concordance between frequent hip pain and radiographic evidence of hip osteoarthritis. Radiographs showed a sensitivity of 15.6% and specificity of 90.9% for radiographic hip osteoarthritis; the positive predictive value was 20.7% and negative predictive value 87.6% (see supplementary figure 1).

For the diagnostic test of radiographs for clinical symptoms of hip osteoarthritis, the sensitivity of radiographic hip osteoarthritis for hip pain localized to the groin was 36.7%, specificity 90.5%, positive predictive value 6.0%, and negative predictive value 98.9% (table 2). The sensitivity of radiographic hip

osteoarthritis for hip pain localized anteriorly was 24.4% and specificity 90.4% (table 2). Similarly, the sensitivity of radiographic hip osteoarthritis for hip pain localized to the groin or anteriorly was 27.1% and specificity 90.6% (table 2). For participants in the Framingham Osteoarthritis Study, pain with internal rotation during physical examination was also tested. However, despite adding painful internal rotation to the analysis, the agreements of clinical symptoms of hip osteoarthritis and radiographic hip osteoarthritis did not improve. The sensitivity of radiographic hip osteoarthritis for groin or anterior hip pain with painful internal rotation was 33.3% and specificity 90.3% (table 2).

The Osteoarthritis Initiative

Compared with the Framingham Osteoarthritis Study cohort, the Osteoarthritis Initiative cohort had a lower prevalence of radiographic hip osteoarthritis, with definite radiographic hip osteoarthritis present in 7.9%

(95% confidence interval 6.9% to 9.0%) of women and 11.6% (10.2% to 13.2%) of men. The corresponding prevalence of definite and possible radiographic hip osteoarthritis combined was 20.7% (19.1% to 22.3%) for women and 27.3% (25.3% to 29.4%) for men. The prevalence of hip pain was similar to that in the Framingham Osteoarthritis Study, with hip pain reported by 27.5% (25.8% to 29.3%) of women and 18.5% (16.5% to 20.3%) of men. Radiographs from 8732 hips in 4366 participants were evaluated.

Concordance between frequent hip pain and radiographic evidence of hip osteoarthritis. The sensitivity of frequent hip pain for radiographic hip osteoarthritis was 9.1% and specificity 94.3%. The positive predictive value was 23.8% and negative predictive value 84.1% (see supplementary figure 2).

For the diagnostic test of radiographs for clinical symptoms of hip osteoarthritis, the sensitivity of definite radiographic hip osteoarthritis for hip pain localized to the groin was 16.5%, specificity 94.0%, positive predictive value 7.1%, and negative predictive value 97.6% (table 3). The sensitivity of radiographic hip osteoarthritis for hip pain localized anteriorly was 15.3% and specificity 93.9% (table 3). Similarly, the sensitivity of radiographic hip osteoarthritis for hip pain localized to the groin or anteriorly was 15.8% and specificity 94.1% (table 3). When we used possible radiographic hip osteoarthritis as the definition for positive radiographic hip osteoarthritis, radiographic hip osteoarthritis was more sensitive (30.0%) for hip pain localized to the groin or anteriorly, but less specific (81.8%) (table 4).

Discussion

Overall, we found poor agreement between frequent hip pain and radiographic osteoarthritis in the ipsilateral hip in participants in both the Framingham Osteoarthritis Study and the Osteoarthritis Initiative. The study methodologies and populations slightly differed between the two cohorts, but the results were similar. Overall, most patients with frequent hip pain did not have radiographic hip osteoarthritis, and most patients with radiographic hip osteoarthritis did not have frequent hip pain. Although frequent hip pain localized to the groin or anterior thigh is commonly thought to

Table 1 | Characteristics of cohort. Values are numbers (percentages) unless stated otherwise

Characteristics	Framingham Osteoarthritis Study	Osteoarthritis Initiative
Mean (range) age (years)*	63.5 (51-92)	61.0 (45-79)
Women*	528 (55.9)	2532 (58.0)
White ethnicity*	882 (93.2)	3493 (80.0)
Mean body mass index	27.9	28.3
Frequent hip pain†	255 (13.0)	1433 (16.4)
Location of pain†:		
Groin	30 (1.6)	237 (2.7)
Anterior thigh (front of leg)	45 (2.4)	157 (1.8)
Lateral (outside of leg)	126 (6.8)	949 (10.9)
Low back	117 (6.3)	605 (6.9)
Buttocks	50 (2.7)	490 (5.6)
Groin or anterior thigh	59 (3.2)	323 (3.7)
Internal rotation of hip†:		
Frequent hip pain and painful internal rotation	55 (2.7)	NA
Groin pain and painful internal rotation	12 (0.7)	NA
Anterior thigh pain and painful internal rotation	18 (1.0)	NA
Groin or anterior thigh pain and painful internal rotation	21 (1.1)	NA

*Person based prevalence (n=946 people in Framingham Osteoarthritis Study and 4366 people in Osteoarthritis Initiative).
†Hip based prevalence (n=1850 hips in Framingham Osteoarthritis Study and 8732 hips in Osteoarthritis Initiative). Replacement hips excluded.

Table 2 | Radiographic hip osteoarthritis (RHOA) and clinical symptoms of hip osteoarthritis in Framingham. RHOA as diagnostic test. Clinical symptoms of hip osteoarthritis as gold standard (symptoms versus none). Values are percentages (number with symptom/total number)

Clinical symptoms*	Sensitivity % of gold standard hips with RHOA	Specificity % of non-gold standard hips without RHOA	Positive predictive value % of RHOA hips with gold standard	Negative predictive value % of non-RHOA hips without gold standard
Groin pain†	36.7 (11/30)	90.5 (1647/1820)	6.0 (11/184)	98.9 (1647/1666)
Anterior thigh pain†	24.4 (11/45)	90.4 (1632/1805)	6.0 (11/184)	98.0 (1632/1666)
Groin or anterior thigh pain†	27.1 (16/59)	90.6 (1623/1791)	8.7 (16/184)	97.4 (1623/1666)
Frequent hip pain and painful internal rotation	18.0 (9/50)	90.3 (1625/1800)	4.9 (9/184)	97.5 (1625/1666)
Groin pain† and painful internal rotation	33.3 (4/12)	90.2 (1658/1838)	2.2 (4/184)	99.5 (1658/1666)
Anterior thigh pain† and painful internal rotation	27.8 (5/18)	90.2 (1653/1832)	2.7 (5/184)	99.2 (1653/1666)
Groin or anterior thigh pain† and painful internal rotation	33.3 (7/21)	90.3 (1652/1829)	3.8 (7/184)	99.2 (1652/1666)

*All definitions require pain on most days of a month in past year.

†Hips with pain but not in specific location are classified as no pain. Location specific pain includes hips with pain also in other locations.

Table 3 | Definite radiographic hip osteoarthritis (RHOA) and clinical symptoms of hip osteoarthritis in Osteoarthritis Initiative. RHOA (definite) as diagnostic test. Clinical symptoms of hip osteoarthritis as gold standard (symptoms versus none). Values are percentages (number with pain/total number)

Pain definition*	Sensitivity	Specificity	Positive predictive value	Negative predictive value
	% of gold standard hips with RHOA	% of non-gold standard hips without RHOA	% of RHOA hips with gold standard	% of non-RHOA hips without gold standard
Groin pain†	16.5 (39/237)	94.0 (7984/8495)	7.1 (39/550)	97.6 (7984/8182)
Anterior thigh pain†	15.3 (24/157)	93.9 (8049/8575)	4.4 (24/550)	98.4 (8049/8182)
Groin or anterior thigh pain†	15.8 (51/323)	94.1 (7910/8409)	9.3 (51/550)	96.7 (7910/8182)

*All definitions require pain on most days of a month in past year.

†Hips with pain but not in specific location are classified as no pain. Location specific pain includes hips with pain also in other locations.

Table 4 | Possible radiographic hip osteoarthritis (RHOA) and clinical symptoms of hip osteoarthritis in Osteoarthritis Initiative. RHOA (possible) as diagnostic test. Clinical symptoms of hip osteoarthritis as gold standard (symptoms versus none). Values are percentages (number with pain/total number)

Pain definition*	Sensitivity	Specificity	Positive predictive value	Negative predictive value
	% of gold standard hips with RHOA	% of non-gold standard hips without RHOA	% of RHOA hips with gold standard	% of non-RHOA hips without gold standard
Groin pain†	28.3 (67/237)	81.7 (6934/8495)	4.1 (67/1628)	97.6 (6934/7104)
Anterior thigh pain†	29.9 (47/157)	81.6 (6994/8575)	2.9 (47/1628)	98.5 (6994/7104)
Groin or anterior thigh pain†	30 (97/323)	81.8 (6878/8409)	6.0 (97/1628)	96.8 (6878/7104)

*All definitions require pain on most days of a month in past year.

†Hips with pain but not in specific location are classified as no pain. Location specific pain includes hips with pain also in other locations.

emanate from hip osteoarthritis, radiographic hip osteoarthritis was not present in most older people with frequent hip pain located primarily in the groin or front of thigh. Also, radiographic hip osteoarthritis was not present in most older people with groin or anterior hip pain with painful internal rotation. We tested the sensitivity of radiographic hip osteoarthritis for clinical symptoms of hip osteoarthritis, but this also tells us the positive predictive value of clinical symptoms of hip osteoarthritis for radiographic hip osteoarthritis. Indirectly, clinical symptoms of hip osteoarthritis were not predictive of radiographic hip osteoarthritis.

Consensus to confirm the diagnosis of hip osteoarthritis is lacking. However, the mention of hip pain triggers a common diagnostic approach: a health professional performs a physical examination to rule out other causes of the pain then orders a pelvic or individual hip radiograph to confirm osteoarthritis.¹⁸ This assumes that hip pain is predictive of hip osteoarthritis because people with pain in the hip region are likely to have radiographic hip osteoarthritis. Few studies have assessed the concordance between hip pain and radiographic hip osteoarthritis.^{7 8 14 17 19 20} One study reported certain radiographic indices associated with higher prevalence of hip pain, and minimal joint space was reported as the best radiographic criterion for hip pain.²⁰ Although another study reported a lower prevalence of hip pain (7% in women and 10% in men) in UK studies compared with our studies,¹⁴ severe radiographic osteoarthritis was present in 16% of participants with hip pain compared with 3% without hip pain. Also, the odds of having hip pain was higher in patients with severe osteoarthritis (17.4, 95% confidence interval 3 to 102) compared with mild-moderate osteoarthritis (1.4, 0.4 to 4.7).

Limitations of this study

The largest methodological problem in studying osteoarthritis related pain may be the lack of a validated gold standard for ascertaining that the hip pain is due to osteoarthritis.¹⁹ Unlike the knee or the ankle, the hip joint has numerous surrounding and adjacent structures that could cause pain in the hip area, such as pelvic disease or referred pain to the hip region. Birrell¹⁹ studied the construct validity of different approaches to ascertaining hip pain, which included verbal description or visual aid, or both. The combination of both the questionnaires and shaded hip areas on a manikin were superior for association with hip pain indicators (analgesic use, cane use, arthritis consultation) than either questionnaires only or visual aid only.¹⁹ Our studies combined questionnaires with visual aids to ascertain hip pain. However, we did not assess the severity of hip pain or treatment response to hip osteoarthritis (such as response to non-steroidal anti-inflammatory drugs or corticosteroid injections).

Other methodological problems arise from the use of radiographs to assess hip osteoarthritis. Plain radiographs may lack sensitivity to detect hip osteoarthritis. In knees, small osteophytes may be hidden from overlying bony structures in radiographs,²¹ and this may also be true for small hip joint osteophytes. Similarly, detecting small osteophytes in hip radiographs poses additional challenges because of the more complex variations of the “ball and cup” shape of the hip. Overall, overlying structures can vary substantially between people, and anteroposterior standard radiographs do not adequately visualize large areas, especially in the inferior and posterior hip joint. Weightbearing radiographs of the hip have better sensitivity for hip osteoarthritis than

non-weightbearing films, including especially weight-bearing films acquired using a faux profil oblique view.²²⁻²⁴ We did not acquire faux profil views, but these are rarely done as part of the investigations of hip pain in most countries. While weightbearing films may have better sensitivity, the trade-off may be more false positive results and worse specificity (as could be the case for MRI).²⁴ Additional films are not necessarily part of common practice for the primary care practitioner. In the Osteoarthritis Initiative, hip radiographs were acquired supine (using a technique similar to that of most radiology suites). In the Framingham Osteoarthritis Study, we acquired hip radiographs as recommended with participants standing, though this is not routinely performed. The diagnostic performances of hip radiographs were not substantially different in these studies.

Studies of knee MRI in Framingham have shown that scanning can detect cartilage damage in those without radiographic knee osteoarthritis,^{21,25} and this may also be true of the hip. MRI can also detect other abnormalities not seen on radiographs, such as bone marrow lesions, synovitis, and subtle osteophytes.²⁵ No large scale studies have compared hip radiographs with hip MRI, but the few existing studies have shown that hip radiographs are less sensitive in detecting specific features of osteoarthritis than are MRI scans of the hip.²⁶⁻²⁹ In HOAMS (Hip OA MRI scoring systems) studies, hips with a Kellgren-Lawrence grade 0 (no radiographic osteophyte nor joint space narrowing) often showed features of osteoarthritis on MRI (25% of hips with evidence of severe cartilage damage, 33% with synovitis, and 58% with labral tears).²⁸ For elderly people with chronic hip pain in HOAMS, radiographs were not as sensitive in detecting joint space narrowing as MRI scans.²⁹ Though we did not investigate the diagnostic performance of hip MRI, the problems with using MRI to diagnose hip osteoarthritis are likely to be similar to those associated with the knee. In the knee, studies have shown that though MRI is more sensitive than radiography, it is far less specific for abnormalities suggestive of osteoarthritis in most middle aged and older people.²⁵

The definition of radiographic hip osteoarthritis has differed in hip osteoarthritis studies, and only a few epidemiology studies have compared the differing definitions of radiographic hip osteoarthritis.^{2,30-33} The Osteoarthritis Initiative definition derived from the modified Croft definition incorporates more stringent features of hip osteoarthritis (requiring at least joint space narrowing grade >2 and/or osteophyte grade >2), but the Kellgren-Lawrence definition used in the Framingham Osteoarthritis Study is thought to be better associated with osteoarthritis related hip pain and more predictive for total hip replacement.³² However, another study¹⁷ found only minor differences between the Kellgren-Lawrence definition and the Croft definition in predicting total hip replacement, hip pain, and lower extremity disability five years later. Despite differing definitions for radiographic hip osteoarthritis between the Framingham

Osteoarthritis Study and Osteoarthritis Initiative, the results were similar. When a less stringent definition (possible radiographic hip osteoarthritis) was used in the Osteoarthritis Initiative to be more inclusive for detection of hip osteoarthritis, the results did not improve greatly.

The participants recruited for the Osteoarthritis Initiative had or were at risk for knee osteoarthritis, potentially increasing the risk of hip osteoarthritis. Because the positive predictive value and negative predictive value depend on prevalence of the disease, both values in the Osteoarthritis Initiative may be biased. However, the Framingham Osteoarthritis Study was community based and therefore the values are not likely to be biased.

Among limitations of this study are that participants in the Framingham Osteoarthritis Study are mostly white, and the scarcity of members of other race and ethnic groups did not allow for comparisons. This is not true of the Osteoarthritis Initiative, which had larger representations of races. Other limitations include the use of standing long limb films in the Framingham Osteoarthritis Study, which could have led to a slight underestimation of radiographic hip osteoarthritis. However, participants in the Osteoarthritis Initiative had pelvic radiographs, and results were similar to those in the Framingham Osteoarthritis Study. The ascertainment of clinical hip pain differed slightly between the cohorts, but results from the Osteoarthritis Initiative substantiated findings in the Framingham Osteoarthritis Study. Overall, the reproducibility of the discordance between hip pain and radiographic hip osteoarthritis in two different cohorts adds robustness to our findings.

Clinical implications

We identified and assessed people who most clinicians would characterize as possibly having hip osteoarthritis. In patients aged more than 50 years with groin or anterior hip pain, hip osteoarthritis would be highly suspected, and additional painful internal rotation on physical examination would confirm the clinical diagnosis of hip osteoarthritis for most clinicians. Hip pain and painful internal rotation are features included in the American College of Rheumatology clinical classification criteria for hip osteoarthritis.¹¹ Previously, restriction of internal rotation was shown to be the strongest predictor for hip osteoarthritis in a hip range of motion study.⁷ Surprisingly, our inclusion of assessment of reproducible pain with internal rotation did not improve the diagnostic test performance of the radiograph.

In older patients, inadequate recognition of osteoarthritis has consequences. Decreased functional status from osteoarthritis significantly increases morbidity from coronary heart disease, lung disease, diabetes, obesity, falls, frailty, and various other ailments.³⁴ Recently, radiographic hip osteoarthritis in older women was found to be associated with an increased risk of mortality from all cause and

cardiovascular disease among older white women followed for an average of 16 years.³⁵ A low number (1 in 10) of patients with osteoarthritis meet adequate physical activity recommendations. Although it has not been shown that increasing physical activity in patients with osteoarthritis leads to lower mortality, better recognition and early treatment of hip osteoarthritis could lead to diminished mortality. The population of people aged over 60 has more than doubled in the past 30 years, and the cost of osteoarthritis and its morbidities will continue to increase exponentially. Currently, \$185.5bn (£122.00bn; €173.00bn) is the estimated yearly cost of osteoarthritis in the United States.³⁶ Because many patients with hip pain do not have radiographic hip osteoarthritis, a health professional should continue with the evaluation and treatment of osteoarthritis despite negative radiographic findings.

Strengths of this study

Our study has important strengths. The Framingham Osteoarthritis Study was community based and recruitment of participants was without reference to joint problems. Although participants in the Osteoarthritis Initiative were originally recruited for a longitudinal study of knee osteoarthritis, the findings in this cohort replicated the similarly poor concordance between hip pain and radiographic hip osteoarthritis seen in the Framingham Osteoarthritis Study. The validity of our findings is suggested by the strong association of prevalence of hip osteoarthritis with age.¹ We found that women had a higher prevalence of hip pain than men in both the Framingham Osteoarthritis Study and the Osteoarthritis Initiative, and this is consistent with other studies.^{14 37-39}

Conclusion

Hip pain is discordant with radiographic hip osteoarthritis. We showed that pain was not present in many hips with evidence of osteoarthritis on radiography, and many painful hips did not show radiographic evidence of hip osteoarthritis. Most older participants highly suspected of having clinical hip osteoarthritis (both groin or anterior pain and/or painful internal rotation) did not have radiographic hip osteoarthritis, suggesting that many older people with hip osteoarthritis might be missed if diagnosticians relied on hip radiographs. Hip osteoarthritis is common in older people with various comorbidities and has major public health cost burdens; therefore health professionals should continue to evaluate and treat patients with hip pain suggestive of osteoarthritis despite negative radiographic findings.

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Competing interests: All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

Ethical approval: The Framingham study was approved by the institutional review board of Boston University Medical Center. The Osteoarthritis Initiative study was approved by the institutional review board of University of California, San Francisco.

Data sharing: For additional data from the study, contact the corresponding author (bevochan@bu.edu). Additional data from the Osteoarthritis Initiative study are available at <https://oai.epi-ucsf.org/datarelease/>.

Transparency: The manuscript's guarantor (CK) affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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Supplementary information: Venn diagram showing frequency of hip pain and radiographic hip osteoarthritis in Framingham cohort; Venn diagram showing frequency of hip pain and radiographic hip osteoarthritis in Osteoarthritis Initiative cohort