Radiographic evaluation of foot osteoarthritis: sensitivity of radiographic variables and relationship to symptoms

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Summary

Objectives: To evaluate a radiographic atlas for grading foot osteoarthritis (OA) in relation to the relative sensitivity of different radiographic and views and features, and to examine the relationship between radiographic OA and foot symptoms.

Methods: Weightbearing dorso-plantar (DP) and lateral foot radiographs were obtained from 197 people (126 women and 71 men) aged 62–94 years (mean age 75.9, standard deviation [SD] 6.6). The prevalence of OA in five joints (the first metatarsophalangeal joint [1st MPJ], the first cuneo-metatarsal joint [1st CMJ], the second cuneo-metatarsal joint [2nd CMJ], the navicular-first cuneiform joint [N1st CJ] and the tali-navicular joint [TNJ]) was then determined using both views in combination (as recommended in the atlas), or by using either view in isolation. Associations between radiographic OA in individual foot joints and symptoms were then explored.

Results: Joint-specific prevalence of OA using both DP and lateral views was 1st MPJ (42.4%), 1st CMJ (22.6%), 2nd CMJ (60.2%), N1st CJ (39.1%) and TNJ (32.7%). Using only the DP view detected almost all cases of 1st MPJ OA (94.6%), however, the sensitivity was lower for the other joints (31.0–60.7%). Using only the lateral view detected almost all cases of OA (83.8% to 86.9%), with the exception of the 1st MPJ and 1st CMJ (50.9% and 60.7%, respectively). Using either osteophytes (OP) alone or joint space narrowing (JSN) alone showed low sensitivity for all joints (14.3–63.0%), with the exception of OP alone in the DP view for the 1st MPJ and JSN in the lateral view for the 2nd CMJ (83.8% and 84.0%, respectively). Radiographic OA in individual foot joints and the total number of joints affected were both moderately associated with foot symptoms.

Conclusion: Epidemiological and clinical studies should incorporate observation of both OP and JSN from both DP and lateral views to determine the presence of OA in the foot, as the number of cases detected is reduced if only one radiographic feature or view is used. Radiographic foot OA is common in older people and is moderately associated with foot symptoms.

Key words: Osteoarthritis, X-ray, Prevalence, Foot, Pain.

Introduction

Epidemiological studies indicate that 20–30% of people aged over 65 years report foot pain1–5, and approximately 10% attribute foot pain to osteoarthritis (OA) or joint impairment6,7. However, few studies have assessed foot OA using clearly defined radiographic criteria8. The Zoetermeer study9 of 6585 people conducted in the Netherlands reported a 28% prevalence of OA in the first metatarsophalangeal joint (1st MPJ), an 8% prevalence of OA in the lesser MPJs, and a 7% prevalence of OA in the proximal interphalangeal joints in those aged over 40 years, using a Kellgren and Lawrence score of 2 or above as the case definition. The Clearwater Osteoarthritis Study10 used the same case definition and reported a 20% prevalence of 1st MPJ OA in 3436 people aged between 40 and 94 years. Although these studies have provided useful information regarding the prevalence of foot OA, the Kellgren and Lawrence scale has been criticized for placing too much emphasis on the presence of osteophytes (OP) to classify a joint as osteoarthritic11. Furthermore, both the Zoetermeer and Clearwater studies focused on a limited number of foot joints, and based their definition of OA on dorso-plantar (DP) X-rays only.

In response to these limitations, we recently developed a radiographic classification system for OA affecting five commonly affected joints of the foot, based on a standard atlas of characteristic features12. The atlas has two key components. Firstly, it incorporates observations of both OP and joint space narrowing (JSN). Secondly, it uses two radiographic views — DP and lateral. The atlas has been shown to have high levels of agreement within examiners and moderate levels of agreement between examiners12. In designing the atlas, we considered it necessary to incorporate two radiographic views, based on...
our observation that OA features in some joints were more easily visualized in one view compared to the other. Furthermore, previous studies of the knee suggest that OP are more sensitive than JSN for detecting OA. However, the sensitivity of using only one radiographic view or only one radiographic feature in isolation is unknown for joints within the foot. If the use of a single view (either OP or lateral) and/or a single radiographic feature (either OP or JSN) provides similar sensitivity to a combination of two views and both radiographic features, radiation exposure of research participants, the cost, and/or the time to undertake studies of foot OA could be reduced.

An additional issue that needs to be considered in relation to the use of OA atlases is the degree of association between radiographic changes and symptoms. Previous studies of knee joint OA have reported equivocal findings, possibly due to variation in the choice of radiographic views. While earlier studies were limited to observations of tibio-femoral OA from an antero-posterior radiograph, it is now recognized that the addition of a patello-femoral joint observations (using skyline or lateral views) significantly increases the detection of knee OA, and strengthens the association between radiographic changes and symptoms.

To our knowledge, no studies have examined the relationship between radiographic changes and symptoms in the foot. However, it is likely that detection of foot OA will similarly be affected by the selection of radiographic view, and that the choice of view will influence the association between radiographic changes and foot symptoms.

Therefore, the objectives of this study were (1) to evaluate our recently developed radiographic atlas for grading foot OA in relation to the relative sensitivity of using a DP view only, a lateral view only, or a combination of both views, (2) to determine the relative sensitivity of using OP alone, JSN alone, or a combination of both radiographic features, and (3) to explore the relationship between radiographic foot OA and foot symptoms.

Methods

PARTICIPANTS

The sample comprised 197 people (71 men and 126 women) aged between 62 and 94 years (mean 75.9, SD 6.6) who were taking part in a larger study of the effect of OA on balance and falls. Participants were recruited from two sources: a retirement village (n = 87) and a university health sciences clinic (n = 110). The exclusion criteria for this analysis were a history of rheumatoid arthritis or foot surgery, inability to walk household distances without the use of a walking aid, or a score of less than 7 on the Short Portable Mental Status Questionnaire. A previous study of the knee suggested that a score of less than 7 was a poor discriminator of OA.

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There were approximately equal proportions of unilateral and bilateral cases for all joints, with the exception of the 2nd CMJ, which exhibited a greater proportion of bilateral cases (69%).

**INFLUENCE OF RADIOGRAPHIC VIEWS ON OA PREVALENCE**

The prevalence of OA in individual joints using a combination of DP and lateral views (the “gold standard”) compared to the use of one view in isolation is shown in Table II. Using only the DP view detected almost all cases of OA in the 1st MPJ (94.6%). However, the sensitivity was somewhat lower for the other joints (between 31.0% and 60.7% of cases). Using only the lateral view detected almost all cases of OA in all joints (between 83.8% and 87.6%), with the exception of the 1st MPJ and 1st CMJ (50.9% and 60.7%, respectively).

**INFLUENCE OF RADIOGRAPHIC FEATURES ON OA PREVALENCE**

The prevalence of OA in individual joints using a combination of radiographic features (OP and JSN in the “gold standard”) compared to the use of one radiographic feature (in a single view or in either view) is shown in Table III. Using only one radiographic feature in one view demonstrated poor sensitivity to detect OA in all joints (sensitivity ranging from 14.3% to 63.0%). The exception was the use of OP in the DP view in the 1st MPJ and JSN in the lateral view in the 2nd CMJ, which detected 83.8% and 84.0% of cases of OA, respectively. When one radiographic feature in either view was used to detect OA, the sensitivity did improve for all joints. However, this improvement was not large enough to cause any major alteration in sensitivity relative to using one radiographic feature in one view.

**RELATIONSHIP BETWEEN RADIOGRAPHIC OA AND SYMPTOMS**

Of the 197 participants, 41 (21%) reported “foot arthritis” and 73 (37%) reported “foot pain”. Associations between self-reported foot arthritis, foot pain and radiographic foot OA are shown in Table IV. Participants who reported foot arthritis were more likely to have radiographic OA in the 1st MPJ and N1st CJ, and those who reported foot pain were more likely to have radiographic OA in the N1st CJ and the 2nd CMJ. The association between radiographic foot OA and symptoms did not greatly alter when OA was defined using either the DP or lateral view in isolation, compared to the use of both views. However, for both the 1st MPJ and 1st CMJ, stronger associations with reported foot arthritis were found when only the lateral view was used. Participants who reported foot arthritis had a higher median number of joints affected (5 vs 4; \( Z = -2.2, \ P = 0.028 \)). The likelihood of reporting foot arthritis or foot pain increased according to the number of joints affected (see Fig. 2), however, this association was not significant after adjusting for sex and obesity.

**Discussion**

Despite the very high prevalence of foot pain in older people\(^1\)\(^-\)\(^5\), the prevalence and clinical significance of foot pain...
OA have not been studied in detail, and there is little consistency in the literature with regard to how OA in foot joints should be evaluated and documented. The first objective of this study was to evaluate our recently developed radiographic atlas for grading foot OA in relation to the relative sensitivity of using a DP view only, a lateral view only, or a combination of both views. The second objective was to determine the relative sensitivity of using OP alone, JSN alone, or a combination of both radiographic features. The final objective was to determine the relationship between radiographic OA and subjective reports of “foot pain” and “foot arthritis”. In addressing these issues, we hoped to ascertain the most efficient and optimal method of applying the atlas for future clinical and epidemiological studies.

The prevalence of radiographic foot OA in our elderly sample was very high, with 93% of participants exhibiting radiographic changes in at least one foot joint. Joint-specific prevalence rates ranged between 23% and 60%. Comparing these results to previous studies is of limited value, due to differences in case definitions, the variable inclusion of individual joints, and inadequate reporting of age-specific prevalence rates. However, it would appear that selecting a single joint (such as the 1st MPJ) to define foot OA is somewhat limited, as the prevalence was also high in other joints, and multiple joint involvement was common. Nevertheless, it is acknowledged that the prevalence of radiographic foot OA reported here is likely to be an overestimate of the true prevalence of the condition in the general community, as the sample was quite old (mean age 75.9 years), and just over half of the participants (56%) were attending a university health sciences clinic for ongoing management of foot problems.

Consistent with previous studies of the knee and hands, we found that the prevalence of OA varied depending on the number of radiographic views used. As such, the “gold standard” described in the original atlas (i.e., using both DP and lateral views) should be applied wherever possible. If only a DP view is available, reasonably accurate estimates of OA in the 1st MPJ can be obtained (94.6%), however, the sensitivity is substantially lower for the other joints (between 31.0% and 60.7% of cases). If only a lateral view is available, reasonably accurate estimates of OA can be obtained from most joints (between 83.8% and 87.6%), with the notable exception of the 1st MPJ (50.9%) and 1st CMJ (60.7%, respectively). Given that multiple joint involvement of OA in the foot appears to be common and that some joints are more easily visualized in one view compared to the other, the selection of a single radiographic view may fail to detect clinically important radiographic changes.

OP and JSN are two characteristic features of radiographic OA. Our results showed that using either radiographic feature alone did not produce a level of sensitivity that was equivalent to when both features were included in the assessment for any joint within the foot. These results suggest that both OP and JSN are important radiographic features that should each be included in the assessment of each joint when evaluating radiographic foot OA.

Radiographic foot OA in individual joints was moderately associated with reports of “foot arthritis” and “foot pain” after adjusting for sex and obesity, which is consistent with previous studies of OA in the knees and hands. The joint with the strongest association with reported foot arthritis was the 1st MPJ, whereas the joint with the strongest association with reported foot pain was the N1st CJ. It is difficult to ascertain the clinical significance of these associations, as we did not request participants to report the precise location of their symptoms. However, it is possible that participants with 1st MPJ OA were more likely to consider that they had foot arthritis, as this joint has a relatively large range of motion and plays an important role in enabling the smooth transfer of the body over the foot when walking. As such, any limitation to the function of this joint could be perceived as the joint being “stiff and arthritic”. In contrast, radiographic changes in more proximal joints with smaller ranges of motion (such as the N1st CJ and N1st CJ Both 2.0 (1.0–4.2)** 2.4 (1.3–4.3)**

DP 2.7 (1.0–7.1)* 2.8 (1.1–6.7)*

Lateral 2.2 (1.0–4.6) 1.7 (0.9–3.2)

TNJ Both 1.3 (0.6–2.7) 0.8 (0.4–1.6)

DP 0.5 (0.1–2.0) 0.4 (0.1–1.3)

Lateral 1.6 (0.8–3.4) 0.9 (0.5–1.7)

2nd CMJ Both 1.7 (0.8–3.7) 2.2 (1.2–4.3)*

DP 1.1 (0.5–2.6) 1.6 (0.8–3.2)

Lateral 1.5 (0.7–3.1) 1.8 (1.0–3.3)

*P < 0.05, **P < 0.01.

Table IV

Associations between foot OA and radiographic views used. Odds ratios and 95% confidence intervals shown, adjusted for sex and obesity.
for OA23, we acknowledge that the radiographic "gold standard" used in this study to diagnose OA is not a true "gold standard". Therefore, the true sensitivity, and indeed specificity, of the parameters assessed in this study (radiographic views and features) for the assessment of OA within the foot remains unknown.

Further studies are now required to ascertain the prevalence of foot OA in the general community. On the basis of our results, we suggest that future epidemiological studies should incorporate both DP and lateral views using both OP and JSN to ensure optimum detection of foot OA in each of the five major joints. However, existing epidemiological datasets involving only DP views would seem to be sufficient for the analysis of the 1st MPJ, as based on our findings, 94.6% of cases will be detected when this view is used in isolation.

Conflict of interest

Each of the authors declares that they have no conflicts of interest.

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