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BRIEF REPORT

Identification of Radiographic Foot Osteoarthritis: Sensitivity of Views and Features Using the La Trobe Radiographic Atlas

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Objective. To compare the sensitivity of alternative case finding approaches for the identification of foot osteoarthritis (OA) based on the La Trobe radiographic atlas.

Methods. This was a cross-sectional study of 533 adults age ≥50 years with foot pain in the past year. Weightbearing dorsoplantar (DP) and lateral radiographs were taken of both feet. The La Trobe radiographic atlas was used to document the presence of osteophytes (OPs) and joint space narrowing (JSN). The prevalence of OA in each joint was documented using both views and features in combination (as recommended in the original atlas), and by using a single view (DP or lateral only) and a single feature (OP or JSN only).

Results. Compared to the recommended case definition based on OPs and JSN using both views, a DP-only view identified between 15% and 77% of OA cases, while a lateral-only view identified between 28% and 97% of OA cases. Compared to the recommended case definition of using both features, using only OPs identified between 46% and 94% of OA cases, while using only JSN identified between 19% and 76% of OA cases.

Conclusion. Applying the La Trobe radiographic atlas but using only 1 radiograph view (DP or lateral) or 1 feature (OP or JSN) in isolation misses a substantial number of OA cases, and the sensitivity of these approaches varies considerably between different foot joints. These findings indicate that, where possible, the atlas should be administered according to the original description to avoid under-ascertainment of radiographic foot OA.

INTRODUCTION

Osteoarthritis (OA) is a leading cause of pain and disability and most commonly affects the knees, hips, hands, and feet (1). Although OA affecting the knees, hips, and hands has received considerable research attention, foot OA has been largely ignored until relatively recently (2), despite being highly prevalent (3), disabling (4), and accounting for a substantial number of primary care consultations (5). A key barrier to progress with foot OA research has been the absence of a standardized case definition, with previous studies assessing different combinations of foot joints and using a range of radiographic classification criteria (6). As a consequence of this inconsistency, prevalence estimates of radiographic foot OA have varied widely (6).

To address this issue, a foot-specific atlas (the La Trobe Radiographic Atlas of Foot Osteoarthritis) was developed in 2007 (7). The atlas enables the documentation of radiographic OA in 5 foot joints according to the presence of osteophytes (OPs) and joint space narrowing (JSN) from dorsoplantar (DP) and lateral views, and has since been adopted for use in several population-based studies (8–10). Due to the substantial

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SIGNIFICANCE & INNOVATIONS

- Applying the La Trobe Radiographic Atlas using only 1 radiographic view (dorsoplantar or lateral) misses a substantial number of osteoarthritis (OA) cases.
- Applying the La Trobe Radiographic Atlas using only 1 radiographic feature (osteophytes or joint space narrowing) misses a substantial number of OA cases.
- The atlas should be administered according to the original description to avoid under-ascertainment of foot OA.

variability in the bony morphology of foot joints, the authors of the original atlas recommended using both radiographic views and features in combination to identify foot OA, and in a subsequent publication demonstrated that using only 1 view or feature in isolation missed a substantial number of cases (11). However, because this analysis was undertaken by the developers of the atlas on a convenience sample of older adults with a high prevalence of foot OA, we consider replicating this finding to be important, using an independent assessor to determine whether this low sensitivity would also be reflected in a more representative, population-based sample.

If a single radiographic view and/or feature could identify a similar number of cases to a combination of both views and features, foot OA research could potentially be conducted more efficiently. Therefore, the objective of this study was to compare the sensitivity of alternative case definitions for the identification of foot OA based on the La Trobe atlas using data from the Clinical Assessment Study of the Foot, a large, population-based study conducted in the UK (8).

MATERIALS AND METHODS

Study design. Data were collected via a population-based health survey and research assessment clinic as part of the Clinical Assessment Study of the Foot (8). Adults age ≥50 years registered with 4 general practices were invited to take part in the study, irrespective of consultation for foot pain or problems. Ethical approval was obtained from the Coventry Research Ethics Committee (#10/H1210/5). All eligible participants were mailed a Health Survey questionnaire that gathered information on demographic and social characteristics and general health. Participants who reported pain in and around the foot in the past 12 months and provided written consent to further contact were invited to attend a research clinic where radiographs were obtained.

Radiographic assessment of foot OA. Bilateral weight-bearing plain film radiographs were taken according to standardized protocols (8). The participant stood in a relaxed position with their weight distributed equally across both feet. For the DP projection, the radiograph tube was angled 15° cranially with a vertical central ray centered at the base of the third metatarsal. For the lateral projection, the radiograph tube was angled at 90° with a horizontal central ray centered on the base of the first metatarsal (7). The presence of OPs and JSN was assessed in 5 joints: the first metatarsophalangeal (MTP) joint, the first cuneometatarsal (CM) joint, the second CM joint, the navicular–first cuneiform (N-1st C) joint, and the talonavicular (TN) joint. For each joint, the presence of OPs and JSN was graded from 0 to 3 on both DP and lateral views, with the exception of TN joint OPs, where only the lateral view was used, as OPs most commonly develop on the dorsal aspect of this joint, which is difficult to visualize from a DP view (11).

The presence of radiographic OA in each joint was documented using 5 different case definitions: 1) a score of ≥2 for either OPs or JSN from either the DP or lateral view (as recommended in the original atlas), 2) a score of ≥2 for either OPs or JSN from the DP view only, 3) a score of ≥2 for either OPs or JSN from the lateral view only, 4) a score of ≥2 for OPs only from either the DP or lateral view, and 5) a score of ≥2 for JSN only from either the DP or lateral view.

All radiographs were initially graded using the original case definition by a single reader (MM) with previously documented intraexaminer reliability (3). To establish the inter- and intraexaminer reliability of the different case definitions based on individual views and features, HBM and MM independently scored radiographs from 60 randomly selected participants (n = 120 feet).

Statistical analysis. Analyses were conducted using SPSS Statistics, version 25, and Stata SE, version 14.2. The number of OA cases in each joint identified according to the case definitions using individual views and features were expressed as a percentage of cases defined using the original atlas description. The inter- and intraexaminer reliability of the different case definitions were calculated using Gwet's AC1 kappa (12) and percentage agreement statistics.

RESULTS

Study population. As previously reported, a total of 5,109 completed Health Survey questionnaires were received (adjusted response 56%) (3). Of these, 1,635 individuals who reported pain in and around the foot in the past 12 months and who provided written consent were invited to the research assessment clinic and 560 attended. Individuals with inflammatory arthritis (n = 24) were excluded from this analysis, and foot radiographs were unavailable for 3 participants, leaving a total of 533 eligible participants (1,066 feet) (235 men and 298 women with a mean ± SD age of 65 ± 8 years).

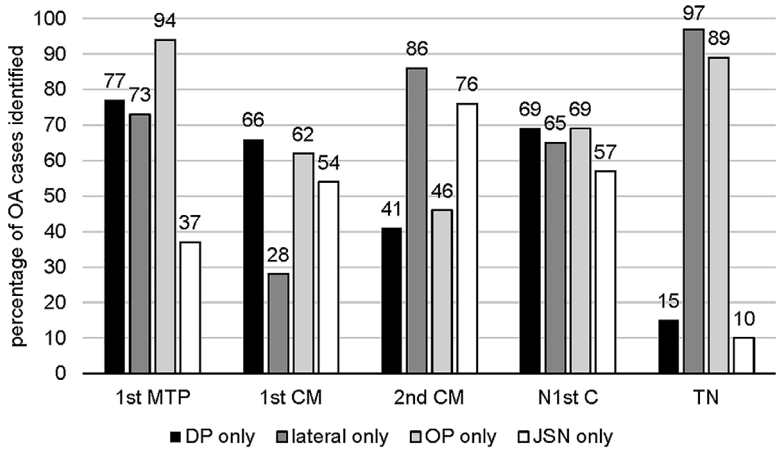

Figure 1. Foot OA cases identified according to individual radiographic views and features as a percentage of cases defined using the original atlas description (n = 1,066 feet). CM = cuneometatarsal; DP = dorsoplantar; JSN = joint space narrowing; MTP = metatarsophalangeal; N1st C = navicular–1st cuneiform; OA = osteoarthritis; OP = osteophytes; TN = talonavicular.

Foot OA cases identified with different case definitions. The prevalence of radiographic OA in each joint according to the original atlas case definition was as follows: 1st MTP joint (n = 294, 27.6%), 1st CM joint (n = 50, 4.7%), 2nd CM joint (n = 50, 4.7%), N-1st C joint (n = 86, 8.1%), and TN joint (n = 158, 14.8%). Figure 1 shows OA cases for each joint identified according to individual views and features as a percentage of cases defined using the original atlas description. Compared to the recommended case definition based on OPs and JSN using both views, a DP-only view identified between 14.5% and 77.2% of OA cases. The highest sensitivity was for the 1st MTP joint and the lowest was for the TN joint. Using a lateral-only view identified between 28% and 96.8% of OA cases. The highest sensitivity was for the TN joint and the lowest was for the 1st CM joint. Compared to the recommended case definition of using both features, using only OPs identified between 45.7% and 94.2% of OA cases. The highest sensitivity was for the 1st MTP joint and the lowest was for the 2nd CM joint. Using only JSN identified between 19.0% and 76.1% of OA cases. The highest sensitivity was for the 2nd CM joint and the lowest was for the TN joint. Figure 2 shows the relative frequency of radiographic features classifying joints as having OA using the original atlas description.

Reliability of different case definitions. Tables 1 and 2 show the intra- and interexaminer reliability of foot OA assessment using the different case definitions. Reliability was similarly high across different combinations of views and features (κ ranging from 0.923 to 1.000 for intraexaminer reliability and 0.705 to 1.000 for interexaminer reliability).

DISCUSSION

The objective of this study was to compare the sensitivity of alternative case-finding approaches to the identification of foot

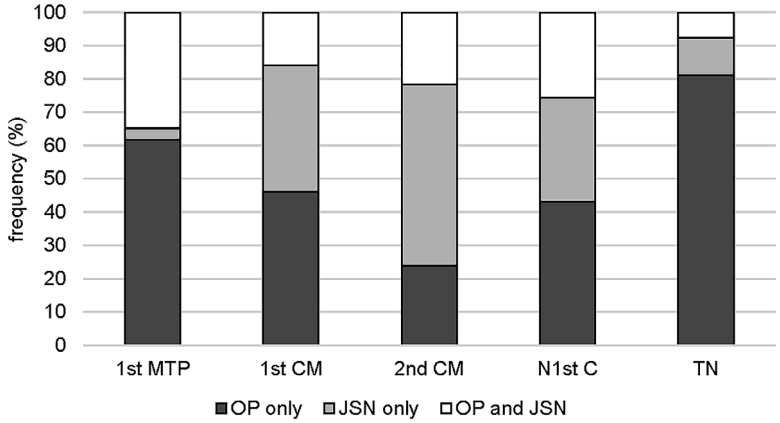

Figure 2. Relative frequency of radiographic features classifying joints as having osteoarthritis using the original atlas description (both views, n = 1,066 feet). CM = cuneometatarsal; JSN = joint space narrowing; MTP = metatarsophalangeal; N1st C = navicular–1st cuneiform; OP = osteophytes; TN = talonavicular.

Table 1. Intra- and interexaminer reliability of foot osteoarthritis assessment using different case definitions according to radiographic view (n = 120 feet)*

	Intraexaminer reliability			Interexaminer reliability		
Joint	Both DP and lateral	DP only	Lateral only	Both DP and lateral	DP only	Lateral only
1st MTP	0.923 (96)	0.860 (91)	0.911 (94)	0.705 (81)	0.868 (90)	0.915 (93)
1st CM	0.960 (97)	0.971 (98)	0.991 (99)	1.000 (100)	0.992 (99)	1.000 (100)
2nd CM	0.942 (96)	1.000 (100)	0.935 (95)	0.802 (84)	0.974 (98)	0.843 (87)
N-1st C	0.979 (98)	0.991 (99)	0.991 (99)	0.916 (93)	0.956 (96)	0.992 (99)
TN	0.950 (97)	0.982 (98)	0.950 (97)	0.923 (93)	1.000 (100)	0.964 (97)
Mean κ	0.951	0.961	0.956	0.869	0.958	0.942

* Values are the kappa (% agreement), unless indicated otherwise. Kappa value is Gwet's AC1 kappa. CM = cuneometatarsal; DP = dorsoplantar; MTP = metatarsophalangeal joint; N-1st C = navicular–first cuneiform; TN = talonavicular.

OA based on the La Trobe atlas (7). We found that compared to the recommended case definition based on identifying OPs and JSN from DP and lateral views, using only 1 feature or view in isolation missed a substantial number of OA cases, and the impact of this varied considerably between joints. These findings suggest that where possible, the atlas should be administered according to the original description to avoid under-ascertainment of radiographic foot OA.

During the development of the original atlas, the inclusion of 2 radiographic projections was justified on the basis that due to differences in bony morphology, the DP view would provide the greatest clarity for some joints, whereas the lateral view would be more suitable for others (7). This is clearly demonstrated in our findings. For example, using the DP view in isolation demonstrated moderate sensitivity for the 1st MTP joint (77%) but very low sensitivity for the TN joint (15%). In contrast, using the lateral view in isolation demonstrated high sensitivity for the TN joint (97%) but low sensitivity for the 1st CM joint (28%). Of the 5 joints evaluated, only the 1st MTP joint demonstrated similar sensitivity when either view was used, as OPs, the most dominant feature of 1st MTP joint OA, are often visible on both the dorsal and mediolateral aspects of the joint.

The inclusion of 2 features, OPs and JSN, appears to be necessary for assessing foot OA due to variation in how OA manifests in individual joints. For example, OA in the 1st MTP joint is characterized by the formation of large OPs, whereas the 2nd CM joint, possibly due to its more proximal location in the foot and limited range of motion, is more likely to develop JSN. If the atlas was applied using OPs in isolation, most cases of 1st MTP joint (96%) and TN joint (89%) OA would be identified, but a substantial number of cases in the remaining joints would be missed. Similarly, using JSN in isolation would provide moderate sensitivity for the 2nd CM joint (76%), but unacceptably low sensitivity (10–57%) for the remaining joints.

Despite substantial differences in sample characteristics and the prevalence of radiographic OA in each foot joint, our findings in relation to the sensitivity of views and features are consistent with those reported in the original atlas (11). The atlas was developed using a convenience sample of people ages 62–94 years (mean age 76 years) and reported a higher prevalence of radiographic OA in individual joints (ranging from 22% for the 1st CM joint to 60% for the 2nd CM joint) than our population-based sample of people age ≥50 years. However, the relative proportion of OA cases identified using limited views or features was similar, as was the overall representation of OPs and JSN across the different joints. A notable difference was the sensitivity of identifying 1st MTP joint OA using the DP view only, which was higher in the original atlas study than in the current study (95% compared to 77%). This finding suggests that the using the DP view alone may be less sensitive in identifying 1st MTP joint OA in a younger population.

Table 2. Intra- and interexaminer reliability of foot osteoarthritis assessment using different case definitions according to radiographic feature (n = 120 feet)*

	Intraexaminer reliability			Interexaminer reliability		
Joint	Both OP and JSN	OP only	JSN only	Both OP and JSN	OP only	JSN only
1st MTP	0.923 (96)	0.923 (96)	0.981 (98)	0.705 (81)	0.772 (84)	0.959 (97)
1st CM	0.960 (97)	0.991 (99)	0.972 (98)	1.000 (100)	1.000 (100)	0.992 (99)
2nd CM	0.942 (96)	0.981 (98)	0.957 (97)	0.802 (84)	0.966 (97)	0.964 (97)
N-1st C	0.979 (98)	0.991 (99)	0.981 (98)	0.916 (93)	0.966 (97)	0.992 (99)
TN	0.950 (97)	0.952 (97)	1.000 (100)	0.923 (93)	1.000 (100)	0.982 (98)
Mean κ	0.951	0.968	0.978	0.869	0.941	0.978

* Values are the kappa (% agreement), unless indicated otherwise. Kappa value is Gwet's AC1 kappa. CM = cuneometatarsal; JSN = joint space narrowing; MTP = metatarsophalangeal joint; N-1st C = navicular–first cuneiform; OP = osteophyte; TN = talonavicular.

Our findings provide further evidence to support the application of the La Trobe atlas as originally described. However, there are several inherent limitations of the atlas that warrant consideration. First, the atlas is limited to 5 foot joints. These joints were selected based on their suspected susceptibility to the development of OA, but also due to their ease of visualization using DP and lateral radiographs (7). Joints not represented in the atlas (including the subtalar joint, lateral tarsal joints, and interphalangeal joints) are also known to develop OA (6), but additional radiographic views would be required to adequately identify changes in these joints. Second, as with all radiographic atlases, there is some degree of subjectivity involved (13), although reliability has repeatedly been demonstrated to be acceptable both within and between examiners (3,7). Third, the atlas is limited to observations of OPs and JSN, and does not include other frequently observed features of OA such as subchondral sclerosis and cysts (14). Finally, all study participants had current/recent foot pain.

In summary, this study has shown that when applying the La Trobe atlas to identify foot OA, using only 1 radiographic view or 1 feature in isolation misses a substantial number of OA cases, and the sensitivity of these approaches varies considerably between different foot joints. These findings indicate that, where possible, the atlas should be administered according to the original description to avoid under-ascertainment of radiographic foot OA.

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AUTHOR CONTRIBUTIONS

All authors were involved in drafting the article or revising it critically for important intellectual content, and all authors approved the final version to be submitted for publication. Dr. Menz had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study conception and design. Menz, Munteanu, Marshall, Thomas, Peat, Roddy.

Acquisition of data. Menz, Marshall, Thomas, Roddy.

Analysis and interpretation of data. Menz, Munteanu, Marshall, Thomas, Rathod-Mistry, Peat, Roddy.

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