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Article type   : Brief Report

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

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Declaration of interests: none.

ABSTRACT

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

Cross-sectional study of 533 adults aged ≥50 years with foot pain in the past year. Weightbearing dorso-plantar (DP) and lateral x-rays were taken of both feet. The La Trobe radiographic atlas was used to document the presence of osteophytes (OP) and joint space narrowing (JSN). 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 OP 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 OP 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 one x-ray view (DP or lateral) or one 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.

Key words: foot, osteoarthritis, x-ray

Significance and Innovations

- Applying the La Trobe radiographic atlas using only one radiographic view (dorso-plantar or lateral) misses a substantial number of OA cases

- Applying the La Trobe radiographic atlas using only one 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

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 standardised 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 five foot joints according to the presence of osteophytes and joint space narrowing from dorso-plantar (DP) and lateral views, and has since been adopted for use in several population-based studies (8-10). Due to the substantial 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 one 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 it important for this finding to be replicated using an independent assessor and 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 United Kingdom (8).

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 aged ≥50 years registered with four general practices were invited to take part in the study, irrespective of consultation for foot pain or problems. Ethical approval was obtained from Coventry Research Ethics Committee (reference number: 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 weightbearing plain film x-rays were taken according to standardised protocols (8). The participant stood in a relaxed position with their weight distributed equally across both feet. For the DP projection, the x-ray tube was angled 15° cranially with a vertical central ray centred at the base of the third metatarsal. For the lateral projection, the x-ray tube was angled at 90° with a horizontal central ray centred on the base on the base of the first metatarsal (7). Presence of osteophytes (OP) and joint space narrowing (JSN) were assessed in five joints: the first metatarsophalangeal joint (1st MTP joint), the first cuneo-metatarsal joint (1st CM joint), the second cuneo-metatarsal joint (2nd CM joint), the navicular-first cuneiform joint (N1st C joint) and the talo-navicular joint (TN joint). For each joint, the presence of OP and JSN was graded from 0 to 3 on both DP and lateral views, with the exception of TN joint OP, where only the lateral view was used, as OPs most commonly develop on the dorsal aspect of this joint which is difficult to visualise from a DP view (11).

Presence of radiographic OA in each joint was documented using five different case definitions: (i) a score of ≥2 for either OP or JSN from either the DP or lateral view (as recommended in the original atlas), (ii) a score of ≥2 for either OP or JSN from the DP view only, (iii) a score of ≥2 for either OP or JSN from the lateral view only, (iv) a score of ≥2 for OP only from either the DP or lateral view and (v) 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 intra-examiner reliability (3). To establish the inter- and intra-examiner 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 IBM SPSS Statistics Version 25 (IBM Corporation, Armonk, NY) and Stata SE 14.2 (StataCorp, College Station, TX, USA). 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 intra-examiner reliability of the different case definitions were calculated using Gwet's AC1 kappa (κ) (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 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 [standard deviation] age of 65 [8] years).

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%), N1st 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 OP 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 OP 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

Table 1 shows the intra- and inter-examiner 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 intra-examiner reliability and 0.705 to 1.000 for inter-examiner reliability).

DISCUSSION

The objective of this study was to compare the sensitivity of alternative case-finding approaches to the identification of foot OA based on the La Trobe atlas (7). We found that compared to the recommended case definition based on identifying OP and JSN from DP and lateral views, using only one 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 two 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 five 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 medio-lateral aspects of the joint.

The inclusion of two features – OP 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 characterised 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 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 older people aged 62 to 94 years (mean age 76 years) and reported 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 aged 50 years and over. 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 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.

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 five foot joints. These joints were selected based on their suspected susceptibility to the development of OA, but also due to their ease of visualisation using DP and lateral radiographs (7). It is known that joints not represented in the atlas (including the subtalar joint, lateral tarsal joints and interphalangeal joints) also 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 OP 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 one radiographic view or one 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.

AUTHOR CONTRIBUTIONS

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

Acquisition of data. Marshall, Thomas, Roddy.

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

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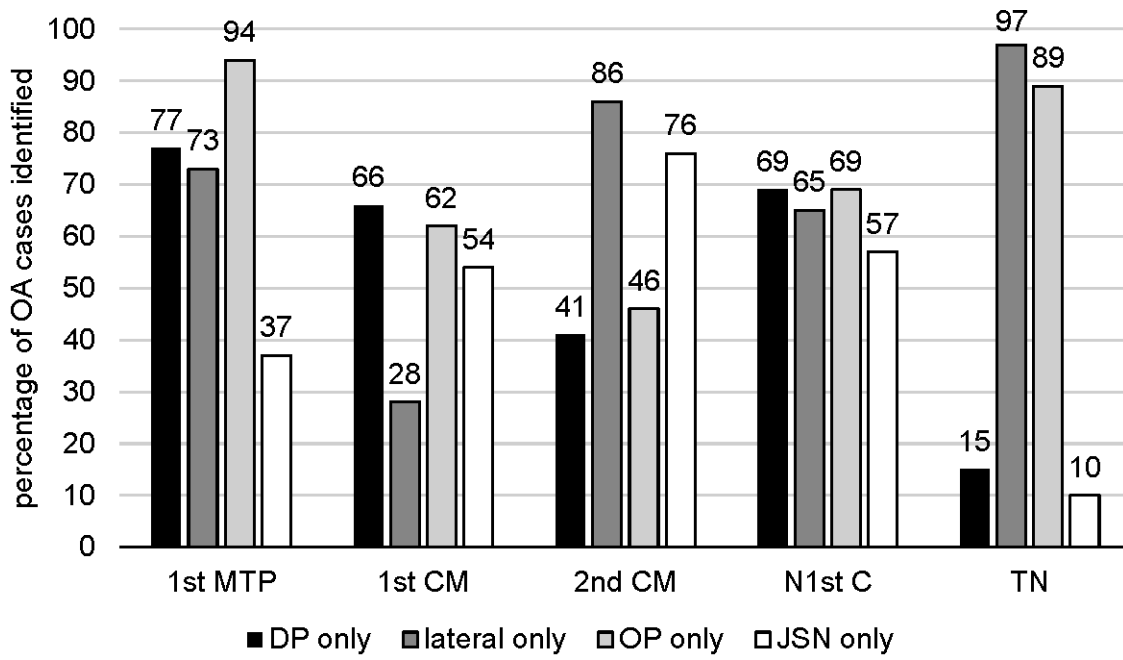
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Table 1. Intra- and inter-examiner reliability of foot OA assessment using different case definitions (n=120 feet).
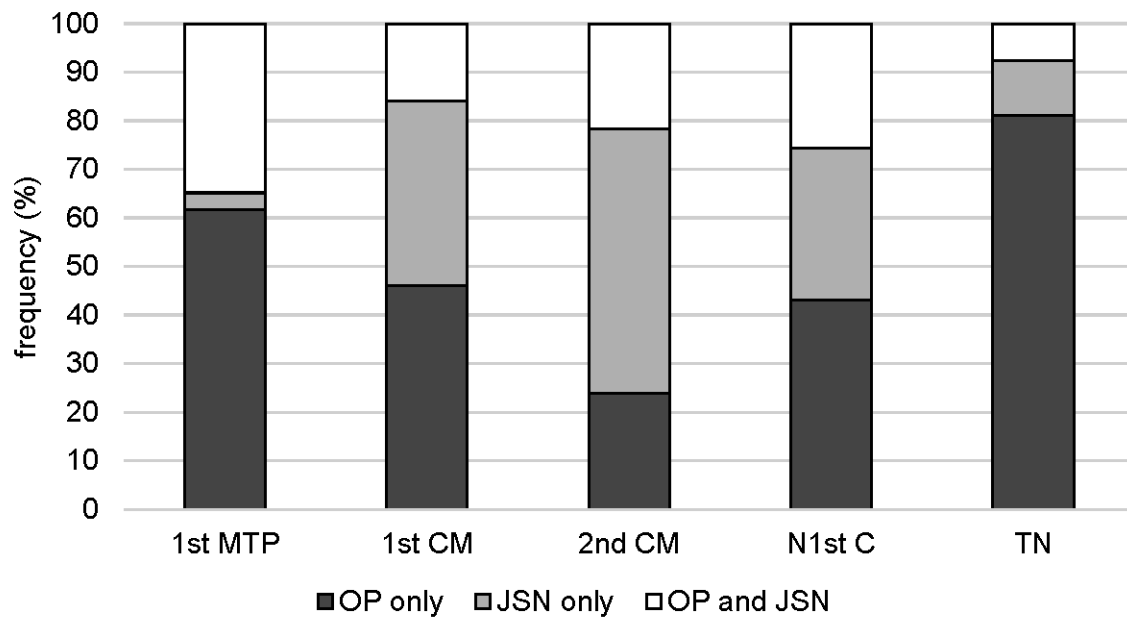
	According to radiographic view					
	Intra-examiner reliability (κ), % agreement			Inter-examiner reliability (κ) % agreement		
Joint	Both DP and lateral	DP only	Lateral only	Both DP and lateral	DP only	Lateral only
1st MTP	0.923, 96%	0.860, 91%	0.911, 94%	0.705, 81%	0.868, 90%	0.915, 93%
1st CM	0.960, 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%
N1st 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
	According to radiographic feature					
	Intra-examiner reliability (κ), % agreement			Inter-examiner reliability (κ) % agreement		
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%
N1st 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

κ: Gwet's AC1 kappa, DP: dorso-plantar, OP: osteophytes, JSN: joint space narrowing, MTP: metatarsophalangeal joint, CM: cuneo-metatarsal, N1st C: navicular-first cuneiform and TN: talo-navicular.

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