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Hand X-ray examination in two planes is not required for radiographic assessment of hand osteoarthritis

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Abstract

Aims: Radiographic imaging is essential in the diagnosis of hand osteoarthritis (HOA); however, it is unknown whether a multiplanar examination would add essential information to dorso-palmar (dp) views alone. This study evaluated whether an additional radiographic view would aid clinicians in the diagnostic process of HOA.

Methods: The dp radiographs of both hands from 159 HOA patients were assessed according to the scores described by Kellgren and Lawrence (K/L). In oblique view images, structures similar to classic ostophytes (OPs) were found, namely bony proliferations on the dorsal and/or ventral margins of joints, and were documented as dorsal/ventral OPs (dvOPs). Function and pain were assessed by applying standardised read-out systems. Logistic regression analysis and Mann–Whitney tests were implemented.

Results: The presence of dvOPs was associated with the degree of joint damage; however, dp views were sufficient to estimate radiographic changes. Only a few joints showed dvOPs as the only structural alteration; nevertheless, in almost all cases, classical radiographic OA changes were found in dp views of other joints of the same or the contralateral hand. The presence of dvOPs did not affect joint function or pain according to established scores, but was associated with radiographic progression in distal interphalangeal joints.

Conclusion: This is the first study to confirm that additional radiographic planes, oblique/lateral views, are not necessary in the diagnostic process in HOA in daily clinical practice. Nevertheless, the presence of dvOPs reflect more severe joint damage and is associated with radiographic progression in HOA; hence, oblique/lateral views could be a useful tool for academic purposes.

Keywords: hand, osteoarthritis, osteophyte, radiographic, X-ray

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Introduction

Osteoarthritis (OA) is seen as the most prevalent joint disorder,[1–3] and the hand is the site most commonly affected by OA.[4–6] Diagnosis is made by clinical and radiological assessment, whereas the main purpose of imaging in hand osteoarthritis (HOA) is to support clinical findings and detect OA changes as accurately and early as possible. Despite the fact that new imaging techniques have been introduced in HOA over the past years, radiographs still represent the gold standard in OA imaging.[7,8] It is one of the basic concepts of radiology that at least two projections are required to evaluate any structure. For hand radiographs, dorso palmar (dp), oblique and lateral views are available,[9] and multiplanar imaging is recommended for routine imaging.[10,11] However, the analysis of additional radiographic planes besides dp views has never been proposed for the purpose of radiographic evaluation of

HOA by international societies; in particular, European League Against Rheumatism (EULAR) and Osteoarthritis Research Society International (OARSI) recommendations for the radiographic diagnosis of HOA even suggest that dp images would suffice in the diagnostic process of HOA.[12,13] This, however, appears to be based on expert opinion, since no respective reference is provided. Nevertheless, radiographic changes of OA have been very well described,[14–18] and several scoring systems have emerged over the years.[17–22] Uniformly, all scores rely on dp views alone to determine OA changes and thereby parallel distinct radiographic scoring systems in other major rheumatic disorders, such as rheumatoid arthritis, psoriatic arthritis or chronic gout, that also make use solely of dp films.[23–26] An exception is a radiographic scoring system for haemochromatosis arthropathy, where dp and oblique views of the hands were studied, although those views were not analysed separately.[27] Consequently, it is unknown whether additional oblique/lateral views would provide essential information improving diagnostics in HOA.

Interestingly, in the diagnosis of knee OA, assessing multiple X-ray planes is very well recommended,[28] and thus the question arises whether an additional radiographic view would be helpful in the diagnostic process of HOA.

Patients and methods

Clinical patient cohort

Patients from our clinical HOA-cohort were screened and included when both dp and oblique view images of the right and the left hand were available.[29] Eventually, we included 159 HOA patients (143 female, 16 male); mean age: 62.5 years, range 40–85 years; patients either fulfilled the American College of Rheumatology classification criteria for hand OA or displayed a Kellgren and Lawrence (K/L) score of >1 in at least one distal interphalangeal (DIP) or proximal interphalangeal (PIP) joint on plain radiographs of the hands.[17,30] Patient characteristics are provided as supplemental data. This study was approved by the Ethics Committee of the Medical University of Vienna (No 2005/459 and 1097/2015).

Patient and public involvement

Patients were included in a clinical HOA-cohort before this study was initiated. However, at the time the patients were included in the cohort, they gave their consent that the recorded data may be used for scientific purposes in the future.

Radiographic assessment

Plain and oblique radiographs were performed using a Philips Optimus 80 X-ray generator according to standard protocols. Radiological assessment was undertaken using IMPAX EE (AGFA Healthcare, Mortsel, Belgium) software.

dp and oblique view films were numbered randomly to be read independently of each other; case numbers, patients' gender and age, as well as epidemiological and clinical data such as handedness, occupation or scores were recorded in a database. The films were then anonymised and blinded radiographs were saved in DICOM (Digital Imaging and Communications in Medicine) format to be read at least 4 weeks after screening. A total of 8970 joints were examined in the dp as well as in the oblique views.

Blinded assessors (KS, GS) were trained to read dp hand radiographs on the basis of the radiological atlases by Altman,[18] Jacobson,[16] and K/L.[17] Briefly, osteophytes (OP), joint space narrowing (JSN), subchondral sclerosis, deformities and erosions were evaluated. We scored dp images of DIP, PIP, metacarpophalangeal (MCP), interphalangeal (IP)-I and carpometacarpal (CMC)-I joints according to the radiographic OA score published by K/L.[17] The severity of HOA was determined by the K/L score (0 no OA, 1 doubtful OA, 2–4 definite OA), with a higher score reflecting more severe joint damage.

Oblique views were assessed 2 weeks after scoring the dp views. Again, OP, JSN, subchondral sclerosis, deformities and erosions were evaluated. Additionally, structures similar to classic OP were found, namely bony proliferations on the dorsal and/or ventral margins of joints and were documented as dorsal/ventral OPs (dvOPs).

Whereas the readers were not allowed to directly compare dp and oblique views at the time of assessment, a comparison was performed after completion of the assessment process to depict those structural changes that were undetectable in dp views and that were dvOPs and erosions. dvOPs and erosions on oblique views were evaluated dichotomously as present or absent.

Intra- and inter-reader variability was assessed by comparing the independent results of two readers (KS/GS). A total of 25 randomly selected dp images were scored as described previously; moreover, 25 randomly selected oblique images were assessed. Both readers were able to reproduce their own readings 4 weeks apart: in oblique views the intraclass correlation coefficients (ICC) ranged from 0.94 (DIP joints) to 1 (MCP joints). The agreement between the two readers was excellent to good, depending on the joint group and imaging technique; ICC in oblique views ranged from 0.81 (DIP joints) to 0.99 (MCP joints) and from 0.7 (MCP joints) to 0.85 (DIP joints) in dp views.

Clinical assessment

Besides routine biometrical data, functional and pain assessment was performed by applying standardised scores [score for assessment and quantification of chronic rheumatic affections of the hands (SACRAH), Functional Index for Hand Osteoarthritis (FIHOA), Cochin hand functional scale in hand osteoarthritis] and recording tender joint count, patients estimation of joint pain and disease activity [visual analogue scale (VAS) 0–100 mm], as well as patients report on morning stiffness duration (minutes).[31–33]

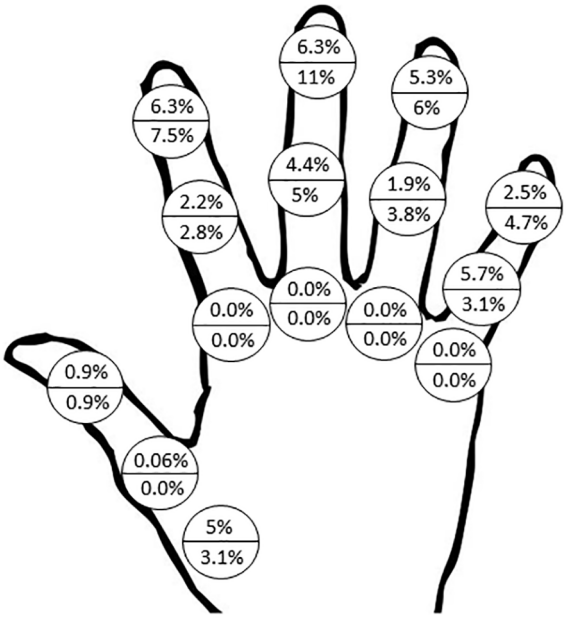

Figure 1. Prevalence of dvOP in the oblique view with regard to the distinct joints of the hands. We examined the radiographs of the DIP, PIP, MCP, IP-I and CMC-I joints in 159 HOA patients. The figure represents data from the left and the right hand; values are provided for both, joints without (K/L score ≤ 1; upper half of the circle) and joints with underlying HOA (K/L score > 1; lower half of the circle).
CMC, carpometacarpal; DIP, distal interphalangeal; dvOP, dorso-ventral osteophytes; HOA, hand osteoarthritis; IP, interphalangeal; K/L, Kellgren/Lawrence; MCP, metacarpophalangeal; PIP, proximal interphalangeal.

Statistical analysis

To predict the probability of the presence of dvOPs and radiographically evident damage, as well as the association between the presence of dvOPs and radiographic progression, a logistic regression analysis was applied. The IP-I joint served as reference joint, as the prevalence of dvOPs war lowest in this joint group.

Mann–Whitney test was used to assess differencies between groups. Analysis was performed using MS Excel 2019 (Microsoft Corporation, Redmond, CA, USA) and SPSS software, version 23.0 (SPSS Inc., Chicago, IL, USA).

Results

Oblique view X-rays and the prevalence of radiographic changes

Structural changes that were seen in in oblique views but were undetectable in dp views, comprised dvOPs as well as erosions. As newly detectable erosions in the oblique views were very rare (0.4%), dvOPs were the emphasis of our further analyses.

The prevalence of dvOPs per joint is presented in Figure 1. Values are provided for both joints without (K/L$\leq$1) and joints with underlying OA (K/L$>$1).

The evaluation of the prevalence data on the joint group level revealed that dvOPs were most prevalent in DIP-joints (12.4%), followed by CMC-I (8.2%) and PIP joints (7.2%). dvOPs were almost absent in MCP-joints (0.06%) and very rare in IP-I joints (1.9%).

Table 1 shows the overall prevalence of dvOPs in those joints with a K/L score$\leq$1 (no/doubtful OA) and those with a score$>$1 (definitive OA).

Relationship between dvOPs and radiographic joint damage

Overall, there seems to be a dependence between joint damage (K/L score) and the presence of dvOPs as joints with dvOPs ($n=276$) showed a higher K/L score (2.02 ± 1.1; mean $\pm$ SD), whereas joints without dvOPs ($n=2586$) displayed a K/L score of 1.5 ± 1.1 (mean $\pm$ SD). The difference

Table 1. Percentage of dvOP in joints without (K/L score ⩽ 1) and joints with underlying HOA (K/L score > 1). PPV and NPV are given with 95% CI.

	DIP joints		DIP joints		CMC-I joints		IP-I joints	
	dvOPs	no dvOPs	dvOPs	no dvOPs	dvOPs	no dvOPs	dvOPs	no dvOPs
K/L ⩽ 1	5.1%	37.7%	3.5%	62.6%	5%	70.8%	0.9%	64.8%
K/L > 1	7.3%	49.9%	3.7%	30.2%	3.1%	21.1%	0.9%	33.4%
PPV	12.79% 11.31% to 14.44%		10.90% 8.98% to 13.19%		12.99% 8.08% to 20.22%		2.75% 1.24% to 6.01%	
NPV	88.07% 85.83% to 90.00%		94.65% 93.46% to 95.63%		93.36% 91.16% to 95.04%		98.56% 96.85% to 99.35%	

CI, confidence interval; CMC, carpometacarpal; DIP, distal interphalangeal; dvOP, dorso-ventral osteophytes; HOA, hand osteoarthritis; IP, interphalangeal; K/L, Kellgren/Lawrence; NPV, negative predictive values; PPV, positive predictive values.

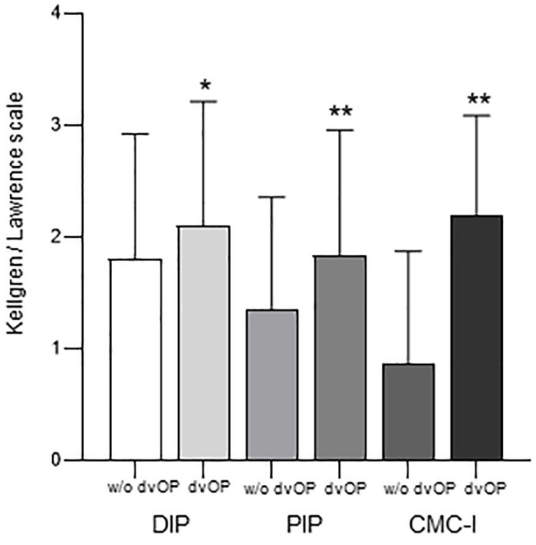

Figure 2. The extent of radiographic joint damage, as reflected by the K/L scale in DIP, PIP and CMC-I joints with and without the presence of dvOP. Values are given as the mean K/L score ± SD. The leftmost pair of columns represents DIP joints, the middle pair PIP joints and the rightmost column-pair CMC-I joints.
*$p < 0.004$; **$p < 0.0001$.
CMC, carpometacarpal; DIP, distal interphalangeal; dvOP, dorso-ventral osteophytes; K/L, Kellgren/Lawrence; PIP, proximal interphalangeal; SD, standard deviation.

was statistically significant ($p < 0.0001$), suggesting more severe joint damage in the presence of dvOPs. The analysis per joint group supported our assumption by revealing a marked difference in the extent of structural damage in DIP joints with dvOPs compared with those DIP joint without dvOPs [K/L score of 2.1 ± 1.1 (mean ± SD) in DIP joints with dvOPs and 1.81 ± 1.12 in DIP joints without dvOPs; $p < 0.004$]. In PIP joints (K/L score of 1.84 ± 1.13 in joints with dvOPs and 1.36 ± 1 in joints without dvOPs) and CMC-I joints (K/L score in of 2.2 ± 0.9 in joints with dvOPs and 0.87 ± 1.01 in joints without dvOPs) the difference between joints displaying dvOPs and such without dvOPs was also significant ($p < 0.0001$), as shown in Figure 2.

Furthermore, logistic regression analysis predicted an association with the presence of dvOPs and the degree of radiographic joint damage for DIP (β: 0.65; $p < 0.0001$) and CMC-I joints (β: 0.41; $p < 0.04$), whereas for PIP joints the association was not significant despite a numeric trend (β: 0.13; $p = 0.35$), as shown in Figure 3. Detailed information on the analysis of maximum likelihood estimates are provided as supplemental data.

When adjusting for age and sex no influence of these parameters on the presence of dvOPs could be seen (data provided as supplemental data).

dvOPs and radiographic progression in HOA

Additionally, follow-up radiographs (mean interval between baseline and follow-up: 30.25 months) from 24 patients with and without dvOP were examined. Our analysis revealed that the presence of dvOPs at baseline predicted radiographic progression for DIP joints (β: 0.45; $p < 0.019$) but not for PIP or CMC-I joints (Figure 4). Detailed information on the analysis of maximum likelihood estimates are provided as supplemental data.

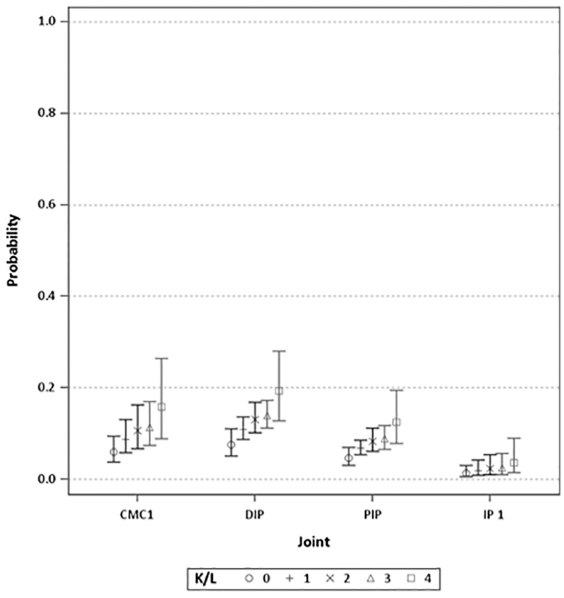

Figure 3. Logistic regression analysis to assess the association between dvOPs and the degree of radiographic joint damage for DIP, PIP and CMC-I joints. The IP-I joint served as reference joint, as the prevalence of dvOPs war lowest in this joint group.
CMC, carpometacarpal; DIP, distal interphalangeal; dvOP, dorso-ventral osteophytes; IP, interphalangeal; PIP, proximal interphalangeal.

dvOPs as the only radiographic feature in HOA

In OA joints, as defined by a K/L score > 1, dvOP were the less frequent changes found and were by far surpassed by classic radiographic changes, OP, JSN and subchondral sclerosis in all three joint groups (Table 2).

However, we recorded 139 (10.9%) DIP joints, 196 (15.5%) PIP joints and 172 (13.5%) CMC-I joints where no radiographic changes could be found in dp views. Out of these joints, 14 (10.1%) DIP, 7 (3.6%) PIP and 3 (1.7%) CMC-I joints displayed dvOPs in oblique views as the only radiographic feature, but even if we found no changes other than a dvOP in a single joint, in almost all of those cases radiographic OA changes were found in other joints of the ipsilateral or the contralateral hand. In one single patient, dvOPs were the only radiographic findings at all. In a consecutive analysis of the available epidemiological and clinical data, no specific pattern could be elucidated and it remains unclear whether dvOPs are to be used as sole markers for HOA in the absence of classical radiographic OA signs.

Table 2. Percentage and distribution of dvOP compared with classic radiographic changes – OP, JSN and subchondral sclerosis – in DIP, PIP and CMC-I joints. The numbers represent the percentage of the distinct alterations with regard to the total of all changes found in osteoarthritic joints.

	DIP joints	PIP joints	CMC-I joints
dvOP	7.8%	4.4%	8.3%
OP	31.9%	34.2%	33.3%
JSN	37.3%	39.6%	25%
subchondral sclerosis	25.6%	21.7%	33.3%

CMC, carpometacarpal; DIP, distal interphalangeal; dvOP, dorso-ventral osteophytes; IP, interphalangeal; JSN, joint space narrowing; OP, osteophytes; PIP, proximal interphalangeal.

Relationship between dvOPs and clinical disease burden

Joint function and joint pain were assessed either by self-reported questionnaires (SACRAH, Cochin, FIHOA) or by clinical examination (tender joint count), at the time X-rays were taken. Moreover, patients estimation of the extent of joint pain and overall disease activity (VAS 0–100 mm) and the duration of morning stiffness of the finger joints (minutes) was recorded.

There was a significant difference between individuals with and without dvOPs in the number of tender joints [number of tender joints (mean ± SD) in patients without dvOPs: 3.2 ± 4.7 *versus* with dvOPs: 5.4 ± 7; $p < 0.05$] and in the duration of morning stiffness of the finger joints [stiffness in minutes (mean ± SD) in patients without dvOPs: 9.5 ± 19.7 *versus* with dvOPs: 24.4 ± 53.6; $p < 0.02$]. However, there was no difference between patients with or without dvOPs in hand radiographs in the validated compound scores, either in joint function, or in joint pain, and just as little in patients estimates of the extent of joint pain or disease activity (Figure 5).

Discussion

Plain radiographs are essential in the diagnostic process of HOA and so far dp radiographs of both hands alone are considered adequate for this purpose, thereby deviating from the general opinion regarding multiplanar radiographic examinations of the hand.[10–12,34,35] Since there is no evidence available on whether to add oblique/lateral views to dp X-rays in the radiographic imaging in HOA, this

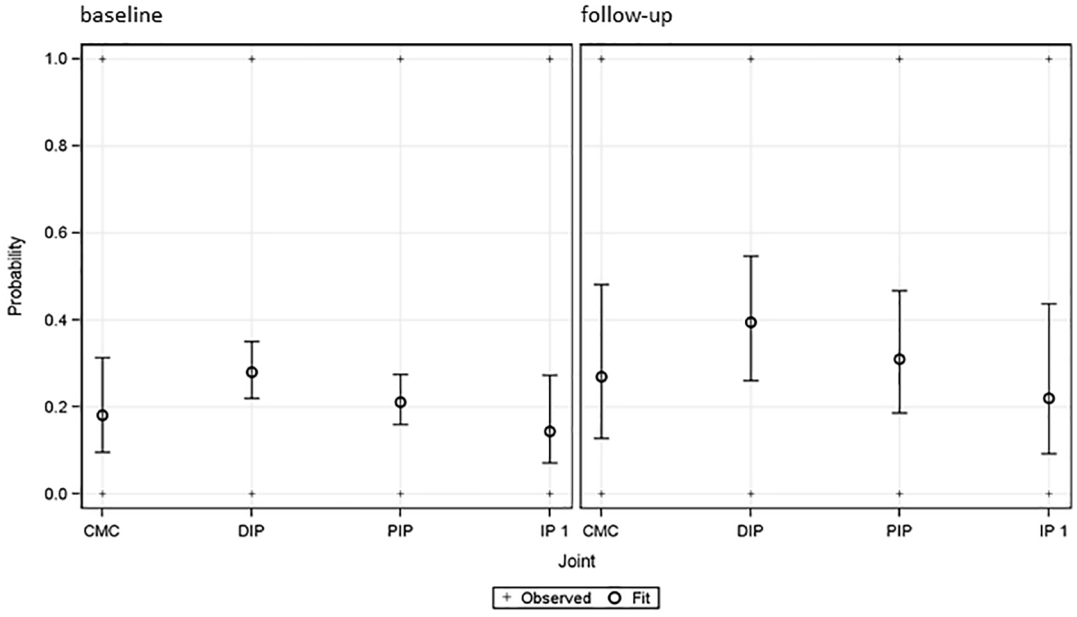

Figure 4. Logistic regression analysis to assess the association between the presence of dvOPs at the baseline X-ray examination and radiographic progression at the follow-up examination for DIP, PIP and CMC-I joints. $n = 24$, mean interval between baseline and follow up: 30.25 months. The IP-I joint served as reference joint, as the prevalence of dvOPs was lowest in this joint group.
CMC, carpometacarpal; DIP, distal interphalangeal; dvOP, dorso-ventral osteophytes; IP, interphalangeal; PIP, proximal interphalangeal.

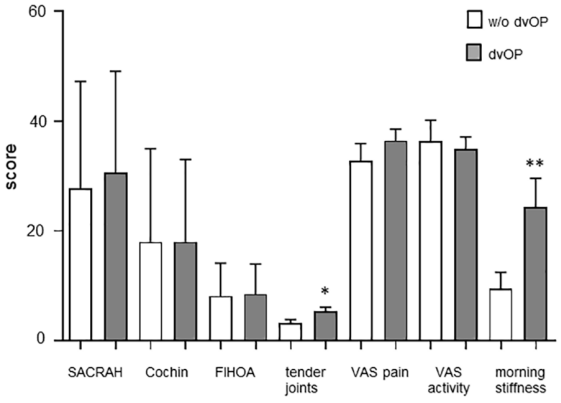

Figure 5. Influence of the presence of dvOPs on the clinical burden of hand osteoarthritis as reflected by standardised scores (SACRAH, FIHOA, Cochin hand functional scale in HOA), tender joint count, patents estimation of joint pain and disease activity (VAS 0–100 mm), as well as patients report on morning stiffness duration (minutes). The white columns represent joints without dvOPs, whereas the grey columns represent joints with dvOPs.
$^{*}p < 0.05$; $^{**}p < 0.02$.
dvOPs, dorso-ventral osteophytes; FIHOA, functional index for HOA; HOA, hand osteoarthritis; SACRAH, score for assessment and quantification of chronic rheumatic affections of the hands; VAS, visual analogue scale.

study evaluated the usefulness of additional images in oblique view in the diagnostic process of HOA.

Reports on the use of oblique/lateral views in the radiographic evaluation of OA changes in the hand-skeleton are scarce. Allenspach *et al.* suggested that lateral images would be more accurate than dp views in detecting osteophytes in finger-joints in a small cohort of rock climbers.[36] A review on the radiographic evaluation of OA postulated that oblique or lateral views would be appropriate to detect dvOP formation in DIP and PIP joints radiographically.[37] dvOPs themselves could be a major feature of HOA,[14,15,37] since a predilection for dvOP-formation exists especially in DIP and PIP joints.[15,37] Moreover, a magnetic resonance imaging study on the assessment of HOA reported the most common site for osteophyte development to be at the bone-cartilage interface of the more proximal phalanx in both PIP and DIP joints, predominantly on the dorsal proximal side of the joint.[38] Interestingly, the evaluation of dvOP never found its way into radiographic atlases, and thus is not implemented in any radiographic scoring system. As a matter of fact, the prevalence and significance of dvOP is actually unknown.

In our HOA-cohort, dvOPs were most prevalent in DIP joints, followed by CMC-I and PIP joints, but occurred far less frequently than classical radiographic signs of HOA, namely OP, JSN and subchondral sclerosis. According to Krishanu and Tan we expected a much higher prevalence of dvOPs.[37,38] Since we made use of oblique views rather than of lateral images in our study, the possibility exists that we might have missed some dvOPs. However, in the standardised oblique view, the joints are very well projected laterally despite the inclined position of the hand. Whereas it cannot be completely ruled out that oblique views may miss some dvOP compared with lateral views, it is unlikely that the detection rate regarding dvOP is significantly affected thereby. Unfortunately, the aforementioned studies did not provide prevalence data on dvOPs, thus a direct comparison is not possible.[37,38]

Still the question remains of whether additional X-ray films in oblique/lateral view would provide useful additional information in the diagnosis of HOA. Indeed, in HOA the presence of dvOPs in oblique views indicates towards more severe joint damage; nevertheless, oblique views did not provide essential additional information over dp views, as the severity of joint damage could also be derived from the dp views alone by applying a score such as the K/L scale. Moreover, dvOPs may be the only radiographic joint alteration to be detected in some joints, but these were very low in number and, in almost all cases, classical radiographic OA changes (OP, JSN, subchondral sclerosis) were found in dp views of other joints of the same or the contralateral hand. Aside from that, it is not at all clear whether the presence of an dvOP can be used as an exclusive surrogate marker for HOA in the absence of classical radiographic signs.

Thus, to answer the question raised previously, our data suggest that additional radiographic views, be they oblique or lateral, do not add essential additional information to dp views in the diagnosis of HOA. Given costs, time constraints and radiation issues, a dp view alone appears absolutely sufficient for diagnostic purposes in daily clinical routine.

However, as the presence of dvOPs was associated with radiographic progression at least in DIP joints, oblique/lateral views could be a useful tool for more accurate damage and disease progression estimation in clinical trials.

In conclusion, and to the best of our knowledge, this is the first study to confirm that an additional radiographic plane (oblique/lateral view) does not add significantly more information in the diagnostic of HOA to that of dp views, which are completely sufficient for this purpose. Hence, routinely performed oblique view scans can be omitted in the diagnostic process of HOA in daily clinical practice, but could be an asset for damage/progression evaluation in trials, cohorts and surveys.

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Author contributions

KS: data acquisition, interpretation of data, manuscript preparation

IGS: interpretation of data, manuscript preparation

CW: interpretation of data, manuscript preparation

AK: data analysis, interpretation of data, manuscript preparation

MB: data acquisition, interpretation of data

GS: data acquisition, interpretation of data

TS: data acquisition, interpretation of data

RW: interpretation of data, manuscript preparation

JSS: interpretation of data, manuscript preparation

KB: study design, interpretation of data, manuscript preparation

Conflict of interest statement

The authors declare that there is no conflict of interest.

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Supplemental material

Supplemental material for this article is available online.

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