

# Ultrasonography (US) of 127 patients with hand osteoarthritis; development of a novel US atlas of osteophytes.

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## ABSTRACT

**Objectives:** Ultrasonography (US) is a sensitive tool for detecting osteophytes (OP) and synovitis in patients with hand osteoarthritis (HOA). Previous studies have introduced a semi-quantitative (0-3) scoring system (none, minor, moderate, and major) of OP and synovitis (grey scale synovitis (GS) and vascularization (power Doppler, PD)). The present objectives were by use of this scoring system to develop an US atlas of OP and explore the presence and degree of US pathology in patients with HOA.

**Methods:** As part of a follow-up study of 127 HOA patients bilateral CMC 1, MCP 1-5, PIP 1-5, DIP 2-5 joints were examined by use of US. Two sonographers performed the assessments together and achieved consensus in the scoring of OP, GS and PD pathology.

**Results:** Of 3771 joints examined, OP was detected in 52.7%, and all patients had OP in at least 4 joints. In joints with OP, the mean (SD) scores were 1.8 (0.7) for CMC1, 1.2 (0.4) for MCP, 1.8 (0.8) for PIP and 2.1 (0.8) for DIP joints, with the DIP joints having the highest scores ( $p < 0.001$ ). A high degree of symmetry was found, with odds ratio of having an osteophyte in one joint when present at the other side was 35.5 (95% CI: 27.4 – 46.1). The presence of GS and PD pathology was found in 15.7% and 2.0% of the joints, respectively. An US atlas of OP in finger joints was developed, including representative images from all joint groups of the hand with each of the scores 0 to 3.

**Conclusion:** All patients had US detected OP with DIP joints having the highest OP scores. Only few patients had presently synovitis. The novel US atlas may be used as a tool for validation studies against other imaging modalities.

Conventional radiographs (CR) provide the standard for morphological assessment of hand OA<sup>6</sup>, and in the guidelines for conduct of clinical trials of HOA, the Osteoarthritis Research Society International (OARSI) group recommend CR as the standard for assessing structural outcomes.<sup>7</sup> However, it is not precluded that other imaging techniques may become more relevant in the future.

US is increasingly recognized as a powerful tool in imaging of OA, due to its accessibility, relatively low cost, and ability to provide details of bone surface and soft tissue. So far there is no universally recognized scoring system for evaluating OA by use of US.<sup>8</sup> However, in 2007 a group of experts in OA and US made consensus on a preliminary scoring system<sup>9</sup> including the evaluation of osteophytes. The presence of OPs are early sign of OA<sup>10</sup> and are easily detected by US. In addition, it has been shown that synovitis with PD activity is frequent in HOA finger joints<sup>11,12</sup> where GS and PD pathology may be assessed by use of a semi-quantitative 0-3 scale as described for patients with rheumatoid arthritis (RA). Use of a US atlas as reference for scoring the degree of GS and PD pathology in RA patients has recently been shown to give high reliability for the semi-quantitative US scoring of several joints<sup>13</sup>, and the synovitis seen in HOA finger joints may thus be scored by use of this US atlas as a reference.

The objectives of the present study were by use of US to explore the presence of osteophytes and inflammation in patients with HOA and use images of osteophytes to develop an US atlas including representative examples of each joint with all the scores for the semi-quantitative scoring system.

## PATIENTS AND METHODS

A total of 127 patients fulfilling the ACR criteria<sup>14</sup> for HOA were included (116 women, mean (SD) age 68.6 (5.8) years and symptom duration 18.3 (7.2) years). The patients were all part of a 6-year follow-up visit for the HOA cohort included at Diakonhjemmet Hospital, where persons with inflammatory rheumatic diseases were excluded. The patients gave written consent according to the Declaration of Helsinki, and the study was approved by the local ethics committee

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OA is a common degenerative joint disease<sup>1</sup> associated with pain and substantial impact on quality of life<sup>2</sup>, significant health economic consequences and use of health care resources.<sup>3,4</sup> Joints most often affected by the disease are knees, hips and hands. The prevalence of symptomatic HOA is estimated to be 6.8% in the adult population, and as high as 26% of women and 13% of men over 70 years.<sup>5</sup>

(the Regional Committee for Medical and Health Research Ethics (REK), South-East).

### US examinations

Two sonographers (one new-beginner and one with nine years of US experience) performed all US assessments together by use of a 5-13MHz linear array transducer (Siemens Antares, Sonoline; Siemens Medical Solutions, California, USA) with fixed settings optimal for PD signals to maximize sensitivity in superficial tissue (pulse repetition frequency 391Hz and frequency 7.3MHz). To ensure standardization, the same US machine and PD setting was used throughout the study, without software upgrading<sup>15</sup>.

The patients were seated with the hands resting on a small table with the finger joints held in neutral position, but passively extended and flexed by the sonographers as required to visualise pathology. The following <sup>15</sup> joints were assessed bilaterally using standard projections<sup>16</sup> (positions described in parenthesis); carpometacarpal (CMC) 1 (palmar to extensor compartment 1), metacarpophalangeal (MCP) 1-5 (dorsal), proximal interphalangeal (PIP) 1-5 (dorsal) and distal interphalangeal (DIP) 2-5 joints (dorsal). All joints were examined with longitudinal scanning from the radial to the ulnar side, and if in doubt use of a transverse scan. Joints with prosthesis or ankylosis were not included.

### Scoring system.

An OP is defined as a cortical protrusion seen in two planes<sup>17</sup>, and the largest of protrusion proximal or distal to the joint space was presently scored. However, if the OPs were smaller, but more widespread, the total amount of protrusions was scored. GS (synovitis and joint fluid scored together) and PD were evaluated according to definitions by OMERACT<sup>18</sup> and scored as described for several RA studies<sup>19 20 21 22</sup> with the US atlas of GS and PD scoring of arthritis as reference<sup>23</sup>. Thus, OP, GS and PD pathology were all scored by use of a semi-quantitative scoring system (0=normal, 1=minor, 2=moderate and 3=major presence).

### Statistical analysis.

All statistical analyses were performed by use of SPSS Statistics 17.0 software (SPSS, Chicago, IL, USA) and Excel 2007 (Microsoft Corporation, Redmond, WA, USA). The descriptive data was given as mean or median  $\pm$  standard deviation (SD), and odds ratio was assessed by logistic regression. Significance was analyzed with unpaired two-tailed t-Test, and considered statistically significant when the p-value obtained was less than 0.05.

### RESULTS

A total of 3771 joints were examined and OP was present in 52.7% of the joints. OP was detected in >

60% of the CMC, PIP and DIP joints, while few MCP joints had OP (table 1). In joints with presence of osteophytes, the mean (SD) scores were 1.8 (0.7) in CMC, 1.2 (0.4) in MCP, 1.8 (0.8) in PIP and 2.1 (0.8) in DIP joints, with significantly larger osteophytes in the DIP joints ( $p < 0.001$ ). As illustrated in figure 1, all patients had OP in  $\geq 4$  joints and half of the patients had more than 16 joints with OP. A large symmetry was presently found, where OP in one joint gave an odds ratio of 35.5 (95% CI 27.4 – 46.1) to have an OP in the symmetrical joint. The dominant hand had no increased prevalence of osteophytes, with mean (SD) number of joints with osteophytes of 8.2 (2.7) in the dominant versus 7.8 (3.0) in the non-dominant hand ( $p = 0.35$ ).

GS synovitis was most frequent in the CMC, PIP and DIP joints, and few patients had synovitis in the MCP joints. However, PD activity was almost only found in the CMC1 joint (table 1). Relative to OP, both GS and PD had lower scores ( $p < 0.001$ ) as well as lower prevalence, with GS and PD pathology seen in 89% and 34% of the patients, respectively (table 2).

An US atlas was developed with representative images of osteophytes in CMC1, MCP, PIP and DIP joints, including several images for each OP score according to the 0-3 semi-quantitative scoring system (figure 2).

### DISCUSSION

A US image atlas of hand OA was created by use of representative images from each joint, describing typical OP grades. The present study found higher percentages of OPs in all examined joint groups, and lower presence of GS and PD compared to previous published ultrasound studies of HOA.

#### Osteophytes

All patients were presently found to have osteophytes in several joints. However, it may be difficult to decide on presence of small osteophytes. To increase the reliability of US scoring of osteophytes, an atlas was developed. In our experience, the most difficult aspect is to decide whether a small lump on the bony surface is to be classified as an OP. Presence or not presence is a crucial distinction for both the patient and especially the statistics in larger studies. It is important to emphasize that an OP has to be a distinct protrusion of the bone, not just a slight elevation. But in MCP joints a convex elevation or bulge at the head of the metacarpals is normal and must not be mistaken for an OP.

Normal shapes of the joints we have examined vary considerably between individuals. A typical grade 1 OP is a single, point and small, yet distinct cortical protrusion of the bony surface. The grade 2 OP are much larger, more elevated and with a broader base than grade 1. They can cover parts of the joint surface, but this is not necessary to achieve this grade. The

huge grade 3 OP almost always covers the entire joint surface, and it can be hard to decide whether it has a proximal or distal origin.

The osteophytes are located to either the proximal or distal part of the joint. In case of several OP present in the same joint, the largest is evaluated and graded. But if it's unclear which of two grades the large OP should have, a smaller one in the same joint can increase the score. And if the OPs were smaller, but more widespread, the total amount of protrusions was scored.

Even though the hand joints are small, their relative size vary; from the small DIP- and PIP-joints, to the larger MCP-joints and the major CMC-joint. When assessing osteophytes, the grade of an OP must be determined according to the size of the joint. Descriptive findings.

The pattern of US-detected pathology that we found was consistent with epidemiological studies of radiographic hand OA<sup>24 25</sup>, with predominance of osteophytes in the DIP joints and base of the thumb, followed by PIP joints and less involvement of the MCP joints. Severity also differed between joint groups, where DIP joints had the relatively largest OPs, in contrast to the MCP joints where few joints had higher score than 1. Synovitis and power Doppler were most often scored toward the lower end of the semiquantitative scale, and most present in the CMC1 joint.

Only a few studies have described the distribution and extent of US-detected pathology. Compared to Keen et al.<sup>26</sup> we found more osteophytes (52% against 41% of the joints), but the distribution was highly corresponding. There was however a discordance when comparing number of joints with synovitis and PD signal, as they found three times higher prevalence for both features (45% against 15% and 7% against 2% of the joints, respectfully). A recently published study by Kortekaas et al.<sup>27</sup> also found more synovitis and PD signal than us, in 22% and 8% of the subjects, respectfully. There might be several reasons for these differences; most important is perhaps age and disease duration. Benito et al.<sup>28</sup> showed considerably more features of inflammation (CD4+ lymphocytes, CD68+ macrophages, ICAM-1, VEGF and blood-vessel formation) in synovial tissue from patients with early OA compared to late OA, and our cohort had higher age and longer disease duration than those in the other studies. Also, our cohort was examined as part of a longitudinal study, and not included from the

outpatient clinic where the disease may be in a more active stage. Furthermore, the number of angles examined differed, which might influence the prevalence of inflammation. We only scanned the dorsal side of the joint, while Keen also looked at the palmar side. The common site for osteophyte development is predominantly on the dorsal proximal side of the joint.<sup>29</sup> There is however little comparable information regarding inflammation. Scheel et al. found more synovitis on the palmar side, but this was in rheumatoid arthritis.<sup>30</sup> Which side that should be scanned needs further investigation.

OA is highly symmetrical. Participants were much more likely to have osteophytes in one joint if an osteophyte was present in the same opposite joint. This strong interrelationship is reflected in the high odds-ratio of 35. Our findings correspond with what is found in other studies of HOA.<sup>31 32</sup> The average number of joints with presence of OP in the dominant hand was similar to that in the non-dominant hand. This symmetry indicates that genetic factors may play an important role in OA.<sup>33</sup> It also raises the question whether it is more feasible to scan only the dominant hand in clinical trials, but this depends on the study design.

Our study has some limitations. The sonographers were not blinded to the diagnosis or clinical features, and the patient was allowed to speak during the examination. Pain and disease duration were topics that often came up during the examinations. But this is probably close to real clinical practice. We also limited the area to examine to the dorsal surface of the hand, perhaps leading to an under-estimation of inflammation.

Ultrasound has become a highly promising technique for the detection of osteoarthritic features, and has several advantages. It offers the ability to (1) obtain dynamic images while moving the patient, (2) do a multiplanar and multiregional evaluation in the same scanning session, (3) evaluate both synovial vascularisation, synovitis and osteopathological features and (4) examine without radiation, invasive procedures or contra-indications.<sup>34 35 36 37 38</sup>

In conclusion, the use of US in hand OA is likely to increase. We have provided a comprehensive collection of pictures illustrating the scoring of osteophytes in different joints of the hand. We believe this can be a useful tool in future assessments of osteoarthritic finger joints with US.

**Table 1** Prevalence of joint abnormalities on a semi-quantitative scale (0-3) in 3771 joints from 127 patients with hand osteoarthritis.

	Score	CMC1	MCP1-5	PIP1-5	DIP2-5	Total
Osteophytes	0	27,9 %	88,2 %	37,9 %	12,5 %	47,3 %
	1	28,8 %	9,8 %	27,5 %	28,4 %	21,9 %
	2	29,2 %	2,0 %	17,9 %	26,2 %	15,5 %
	3	14,2 %	0,1 %	16,7 %	33,0 %	15,4 %
	Score $\geq$ 1	72,1 %	11,8 %	62,1 %	87,5 %	52,7 %
Gray scale synovitis	0	68,7 %	97,8 %	76,4 %	81,2 %	84,3 %
	1	17,6 %	1,4 %	10,0 %	14,2 %	8,7 %
	2	12,9 %	0,6 %	10,1 %	4,3 %	5,5 %
	3	0,9 %	0,2 %	3,5 %	0,4 %	1,4 %
	Score $\geq$ 1	31,3 %	2,2 %	23,6 %	18,8 %	15,7 %
Power Doppler	0	85,4 %	99,6 %	97,5 %	99,3 %	98,0 %
	1	8,6 %	0,2 %	1,4 %	0,5 %	1,2 %
	2	4,3 %	0,2 %	0,9 %	0,2 %	0,7 %
	3	1,7 %	0,0 %	0,2 %	0,0 %	0,2 %
	Score $\geq$ 1	14,6 %	0,4 %	2,5 %	0,7 %	2,0 %

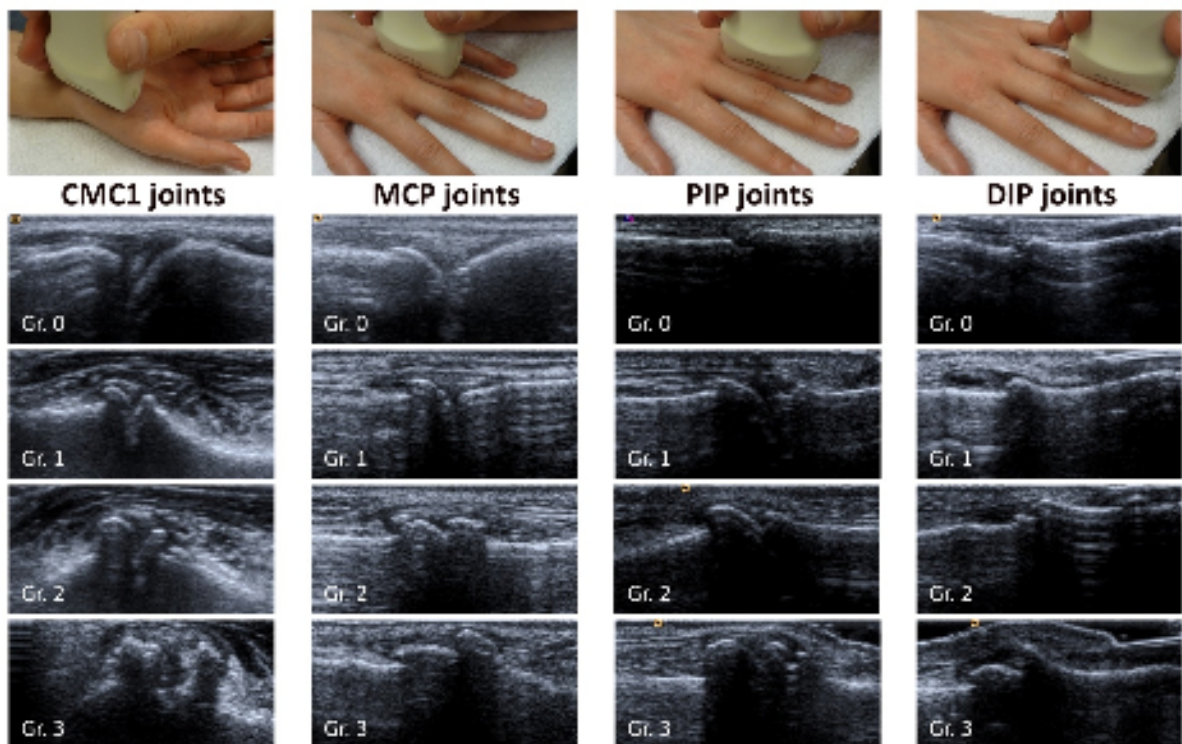
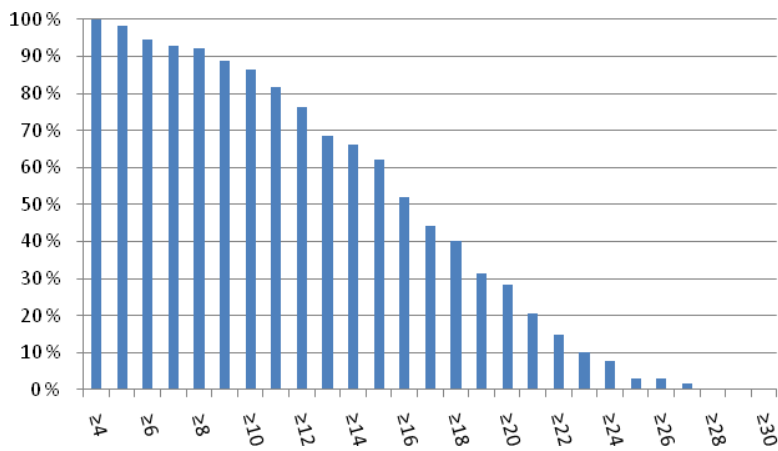
CMC = carpometacarpal joint 1, MCP = metacarpophalangeal joint 1-5, PIP = proximal interphalangeal joint 1-5, DIP = distal interphalangeal joint 2-5.

**Table 2** Prevalence of ultrasound pathology in 127 patients with hand osteoarthritis.

<b>Osteophyte</b>	
Patient (n (%))	127 (100%)
Affected joints (median (range))*	16 (4-27)
Total score (median (range))**	28 (5-65)
<b>Gray scale synovitis</b>	
Patient (n (%))	114 (89,8%)
Affected joints (median (range))*	4 (0-13)
Total score (median (range))**	6 (0-22)
<b>Power Doppler signal</b>	
Patient (n (%))	44 (34,6%)
Affected joints (median (range))*	0 (0-6)
Total score (median (range))**	0 (0-10)

\*Maximum affected joints are 30, and \*\*maximum total score is 90.

**Figure 1** Percentage of the 127 patients with at least 4 of 30 joints with osteophytes.



**Figure 2.** Osteophytes with scores 0 to 3 in carpometacarpal (CMC)1-, metacarpophalangeal (MCP)-, proximal interphalangeal (PIP)-, and distal interphalangeal (DIP) joints.

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