# RESEARCH



# Is thickened hyaline cartilage on ultrasound a sign of osteoarthritis? A within-person, between-joint pilot study

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# Abstract

**Objective** To determine whether the presence of conventional radiography (CR)-detected osteophytes is associated with focal thickening of the hyaline cartilage by ultrasound (US) in the same area of the metacarpal head in a withinperson, between-joint cross-sectional comparison in patients with hand osteoarthritis (HOA).

**Design** 64 patients with HOA (classified using the 1990 ACR classification criteria) were screened. Participants were eligible for inclusion if they displayed osteophytes in at least one of their metacarpophalangeal (MCP) joints, no osteophytes in the contralateral corresponding MCP joint and no joint space narrowing (JSN) in either MCP joint by CR. In these patients, cartilage thickness was measured by US in 2 subregions of both metacarpal heads (i.e., the central force-bearing and the proximal peripheral area). Location-specific association between osteophytes and cartilage thickness was evaluated.

**Results** 14/64 (21.9%) patients and 23 pairs of MCP joints were included in the analysis. Metacarpal heads with osteophytes had significantly thicker hyaline cartilage than contralateral ones without osteophytes in the proximal peripheral area of the hyaline cartilage [0.78 mm and 0.66 mm, respectively (p < 0.01)]. On the other hand, no difference in terms of cartilage thickness was found between the metacarpal heads with osteophytes and the contralateral ones without osteophytes in the central force-bearing area of the hyaline cartilage [0.65 mm and 0.66 mm, respectively (p = 0.53)].

**Conclusions** MCP joints with early radiographic HOA display thicker hyaline cartilage than contralateral MCP joints without radiographic signs of HOA, specifically in the proximal peripheral subregion of the metacarpal head.

# **Key messages**

• Metacarpal heads with early radiographic osteoarthritis display thicker hyaline cartilage than contralateral ones without signs of osteoarthritis.

This ultrasonographic sign should be kept in mind to avoid misinterpretation of cartilage pathologies.We provide pictorial ultrasonographic evidence of this "giant cartilage" sign.

Keywords Articular cartilage, Ultrasound, Metacarpophalangeal joint, Radiography, Osteoarthritis

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# Introduction

The hand is frequently involved in osteoarthritis (OA) [1] with a prevalence of radiographic hand OA up to 50% among subjects older than 50 years of age [1].

Pathological changes of the osteoarthritic joint include thinning and fibrillation of the hyaline cartilage, sclerosis of the subchondral bone, osteophyte formation, synovial inflammation, degeneration of ligaments and joint capsule.

Nevertheless, an increase in cartilage thickness has been observed in animal models during the early phase of OA [2]. However, imaging evidence for cartilage swelling in human OA remains only an intriguing hypothesis. In a magnetic resonance imaging (MRI) study, Cotofana et al. reported that knees without a definite joint space narrowing (JSN) and with osteophytes on conventional radiography (CR) had significantly thicker cartilage than contralateral knees without signs of early OA on CR [3].

Although CR is by far the most common imaging technique used to diagnose OA [4], ultrasound (US) has proven to be a valuable tool in the assessment of hand OA [5–8]. Indeed, US can directly image even subtle changes of the metacarpal head cartilage [8–10] and detect osteophytes earlier than CR in patients with hand OA [11].

The unexpected observation of metacarpal head cartilage thickening overlying an osteophyte in a cohort of healthy controls in a US study of our group prompted us to delve deeper into this matter.

We hypothesize that in metacarpophalangeal (MCP) joints without JSN in patients with hand OA, the presence of osteophytes on CR is associated with focal thickening of hyaline cartilage when measured by US.

# **Materials and methods**

# Study design, population, and inclusion criteria

This cross-sectional study was conducted at the Rheumatology Unit of the Polytechnic University of Marche ("Carlo Urbani" Hospital, Italy) from September 2021 to August 2023.

Patients aged>18 years, without previous fractures or major trauma or surgical procedures at hands level, and with a definite diagnosis of hand OA according to the 1990 American College of Rheumatology classification criteria [12] were consecutively enrolled based on a within-person, between-joint study design. We were unable to use the 2023 EULAR criteria for hand OA [13], as they were published in 2024. Furthermore, the performance of the two criteria sets was similar [13]. All the subjects underwent US and CR assessment of MCP joints 2nd to 5th bilaterally.

We selected patients that fulfilled all of the following criteria as ascertained by CR: had osteophytes in a MCP joint; no osteophytes in the contralateral corresponding MCP joint; and no sign of JSN in either of the two MCP joints.

The study was performed according to the principles of the Declaration of Helsinki and the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement. The study protocol was approved by the local ethics committee (id CERM: 262/2019).

# **CR** assessment

Hands radiographs obtained in postero-anterior view were considered if performed within six months before enrolment. Images were assessed by an expert musculoskeletal radiologist (R.M.M.) blinded to clinical and US imaging data. Osteoarthritic changes were scored using the Kellgren-Lawrence scoring system (KLS): grade 0: no features of hand OA; grade 1: minimal hand OA (questionable osteophyte and/or JSN); grade 2: mild hand OA (small osteophyte and/or mild JSN, sclerosis may be present); grade 3: moderate hand OA (moderate osteophyte and/or moderate JSN, sclerosis and erosions may be present); grade 4: severe hand OA: (large osteophyte and/or severe JSN, sclerosis and erosions may be present) [3, 14].

### US image acquisition and interpretation

US scanning was performed using a MyLab Class C (Esaote SpA, Genoa, Italy), equipped with a 22 MHz linear probe by two expert sonographers (E.F. and E.C.) blinded to clinical data.

The MCP joints 2nd through 5th were scanned bilaterally. A generous amount of gel was applied to avoid compressing superficial tissues hampering their visualisation [15]. Images were acquired according to the EULAR standard scans [15]. Hyaline cartilage of the metacarpal head was scanned on the dorsal aspect of the MCP joints flexed at 90° (closed fist). The probe was maintained in a position so that the US beam was orthogonal to the cartilage surface. To guarantee such perpendicular insonation, care was taken to obtain a sharp and hyperechoic superficial margin of the hyaline cartilage or, in the absence of an evident chondrosynovial interface, to obtain a sharp and hyperechoic subchondral bone profile. Qualitative evaluation of metacarpal head cartilage was made on the basis of a dynamic examination and scored using the following five-grade scoring system [9, 10]: grade 0: normal hyaline cartilage; grade 1: loss of the sharpness of the superficial margin of the hyaline cartilage; grade 2: partial thickness defect of the cartilage layer; grade 3: full thickness defect of the cartilage layer with a normal subchondral bone profile; grade 4: complete loss of the cartilage layer and subchondral bone involvement. The Outcome Measure in Rheumatology (OMERACT) semiquantitative score for cartilage pathology in OA was not adopted since the interobserver reliability was only fair [6]. Quantitative measurements of cartilage thickness were made

on static images acquired using the dorsal longitudinal view both at the central force–bearing portion and at the proximal peripheral part of the metacarpal head as shown in Supplementary Fig. 1. Particular attention was paid to measuring where the cartilage was orthogonally insonated. Callipers were placed to include the chondrosynovial interface and maintain the line of measure perpendicular to the subchondral bony cortex [8–10, 16]. All US pathological findings were confirmed in two perpendicular planes.

# Statistical analysis

Results were expressed as mean  $\pm$  standard deviation for quantitative variables and as number and/or percentage for qualitative variables. The Wilcoxon signed-rank test for matched pairs was used to compare quantitative variables after checking for normality. Two-tailed p values < 0.05 were considered significant. Statistical analysis was performed using STATA v18 (StataCorp, Texas, USA).

# Results

# Patients

We screened 512 MCP joints in 64 patients with hand OA. Their mean age was  $60.2 \pm 6.8$  years, 42 (65.6%) were female, and the mean disease duration since the onset of symptoms was  $3.9 \pm 5.4$  years. Supplementary Material 1 reports the US findings and the CR findings of the 64 screened participants.

#### Within-person, between-joint comparison

We included 14 patients with hand OA who had an osteophyte in a MCP joint, no osteophytes in the contralateral corresponding MCP joint, and no JSN in either MCP joints by CR. A total of 23 pairs of MCP joints were included in the within-person, between-joint analysis.

Table 1 shows the CR findings and US measures of cartilage thickness both at the central force-bearing portion and at the peripheral part of the metacarpal head (at the osteophyte level) and the corresponding measures at the contralateral corresponding metacarpal head without osteophytes.

The mean difference in cartilage thickness between the central force-bearing portion and the proximal peripheral part (at the osteophyte level) was 0.13 mm (95%CI: 0.06 to 0.018, p < 0.01) in joints with CR evidence of osteophytes and no JSN. On the other hand, no difference was observed between the cartilage thickness of the central force-bearing portion and the proximal peripheral part in joints without osteophytes (mean difference 0.01 mm, 95%CI: -0.05 to 0.06, p = 0.95).

No difference was found between the cartilage thickness at the central force-bearing portion in metacarpal heads with osteophytes and without osteophytes (mean difference -0.01 mm, 95%CI: -0.06 to 0.05, p = 0.53) (Table 1). Compared to the contralateral corresponding metacarpal heads without osteophytes, the hyaline cartilage of the proximal peripheral part at the osteophyte level was significantly thicker with a mean increase of 0.12 mm (95%CI: 0.06 to 0.17) p < 0.01).

# **CR findings**

CR revealed a grade 1 of the KLS score in 18 (78.3%) MCP joints and a grade 2 in 5 (21.7%) among the 23 metacarpal heads with osteophytes that were included in the within-person, between-joint comparison.

# US cartilage thickening

US confirmed the presence of osteophytes in each MCP joint included in the analysis. Clear evidence of focal thickening of the hyaline cartilage above an osteophyte was found in 23/512 metacarpal heads (4.5%) of 14/64 OA patients (21.9%). Figure 1 and Supplementary Video S1 provide pictorial evidence of this US finding.

# Discussion

There is increasing interest in imaging findings that enable the early identification of OA from both a basic and a clinical research perspective. A cross-sectional MRI study described a novel pathological finding in the early phases of human knee OA: thickening of the hyaline cartilage [3].

To the best of our knowledge, our report shows the first US evidence of focal thickening of the proximal peripheral portion of the hyaline cartilage in MCP joints with osteophytes but without JSN. We observed a significant increase in the cartilage thickness compared to both the cartilage thickness at the central bearing-force portion of the same metacarpal head and the contralateral hyaline cartilage without osteophytes measured at the same anatomical area. We define this US finding the "giant cartilage" sign.

Interestingly, the great majority of metacarpal heads presenting a focal cartilage thickening did not show advanced signs of OA by US and/or CR.

We can hypothesize that the focal thickening of the hyaline cartilage together with the loss of sharpness of the chondrosynovial interface may be early changes in the natural history of hand OA and they may precede the subsequent cartilage thinning [3, 7, 9]. Indeed, the US evidence of focal thickening of hyaline cartilage and the loss of sharpness of the chondrosynovial margin were found mainly in grade 1 and grade 2 of the KLS. However, this hypothesis requires longitudinal studies for confirmation.

Due to its sensitivity and the capability to directly visualize the hyaline cartilage, US may play a role in the reclassification of joints presenting with a KLS grade 1

	Affected	side – CR evi	idence of oste	sophytes and	no JSN	Unaffect	ed side – CR	evidence of r	neither osteop	hytes nor JSN	Side-by-side comp	arison
	<b>CR KLS</b>	US SQ	HCT in the	HCT in the	HCT	CR KLS	US SQ	HCT in the	HCT in the	HCT	HCT between-dif-	HCT between-
	score	cartilage score <sup>20</sup>	central portion	peripheral portion	within-difference	score	cartilage score <sup>20</sup>	central portion	peripheral portion	within-difference	ference – central portion	difference - peripheral portion
L‡	1	0	0.89	1.06	0.17	0	0	0.96	0.94	0.02	-0.07	0.12
<u></u> ‡2	<del>, –</del>	0	0.70	0.85	0.15	0	0	0.62	0.65	0.03	0.08	0.20
‡2	2	-	0.34	0.47	0.13	0	-	0.44	0.42	0.02	-0.1	0.05
¥3	<i>—</i>	0	0.62	0.84	0.22	0	0	0.68	0.66	0.02	-0.06	0.18
<del>1</del> 3	<del>,</del>	-	0.59	0.79	0.20	0	0	0.71	0.70	0.01	-0.12	0.09
44	<del>,</del>	0	0.79	1.00	0.21	0	0	0.74	0.73	0.01	0.05	0.27
4	2	0	0.62	0.81	0.19	0	-	0.62	0.64	0.02	0	0.17
5	<del>,</del>	-	0.68	0.79	0.11	0	0	0.67	0.68	0.01	0.01	0.11
Ŝ	<i>—</i>	0	0.63	0.73	0.10	0	-	0.66	0.64	0.02	-0.03	0.09
Ŝ	2		0.59	0.71	0.12	0	0	0.62	0.60	0.02	-0.03	0.11
9	<del>,</del>		0.61	0.69	0.08	0	0	0.60	0.63	0.03	0.01	0.06
9	<del>.                                    </del>	0	0.65	0.79	0.14	0	0	0.66	0.65	0.01	-0.01	0.14
2	<del>,</del>	-	0.68	0.79	0.11	0	-	0.67	0.68	0.01	0.01	0.11
õõ	<del>.                                    </del>		0.68	0.79	0.11	0	0	0.67	0.68	0.01	0.01	0.11
6	<del>,</del>	0	0.64	0.73	60.0	0	0	0.61	0.63	0.02	0.03	0.10
10	<del>, -</del>	0	0.70	0.80	0.10	0	0	0.68	0.66	-0.02	0.02	0.14
10	<del>,</del>	-	0.68	0.77	0.09	0	0	0.67	0.68	0.01	0.01	0.09
¢10		0	0.66	0.76	0.10	0	0	0.62	0.64	0.02	0.04	0.12
+11	<del>.                                    </del>	0	0.65	0.76	0.11	0	0	0.63	0.65	0.02	0.02	0.11
:12	<del>.                                    </del>		0.63	0.71	0.08	0		0.65	0.65	0	-0.02	0.06
:13	-	0	0.59	0.67	0.08	0	0	0.62	0.61	-0.01	-0.03	0.06
14	<del>,</del>	-	0.71	0.8	0.09	0	-	0.69	0.70	0.01	0.02	0.10
14	<del>, -</del>	-	0.65	0.75	0.10	0	0	0.64	0.67	0.03	0.01	0.08
ean	~	/	0.65	0.78	0.13	~	/	0.66	0.66	0.01	-0.01	0.12



Fig. 1 Focal cartilage thickening in the presence of an osteophyte and healthy metacarpal head cartilage. *Legend*. Ultrasound dorsal longitudinal scan of the hyaline cartilage of the 2nd metacarpal head moving the probe from the central force-bearing portion (**A**, **D**) to the proximal peripheral part of the metacarpal head (**C**, **F**) in a patient with hand osteoarthritis (**A-C**) and in a healthy control (**D-F**). **Arrow**: osteophyte, **arrowheads**: hyaline cartilage's superficial margin, **m**: metacarpal head, **p**: proximal phalanx

(i.e., normal joint or doubtful JSN with or without definite osteophyte) by the identification of early cartilage changes. Moreover, the "giant cartilage" sign should be kept in mind when evaluating cartilage damage both with semiquantitative scoring system and quantitative assessment to avoid misinterpretation of US findings (i.e., false negative results). Finally, the focal thickening of the hyaline cartilage may explain, at least in part, the initial difficulty in obtaining good interobserver reliability of the OMERACT scoring system of cartilage damage in hand OA in a previous OMERACT study [6].

Although the sample size of the study is relatively small, the use of a within-person, between-joint design is a major strength of the study. This design implicitly controls for confounding as the same US findings were compared within the same group of patients. In a previous study, we have already demonstrated that the hyaline cartilage of the metacarpal heads has a comparable thickness in the dominant and the non-dominant hand [9]. However, patients with a clinical diagnosis of hand OA were excluded from that study. Therefore, we were unable to elvaluate the impact of hand dominance.

However, we must acknowledge some limitations. First, all CR images were evaluated by a single musculoskeletal radiologist. In addition, the use of CR to select patients have introduced a selection bias. However, this is an expected "side effect" of this study design that was required to test our hypothesis using a "within-person between-joint" design. Second, the US findings were not confirmed by another advanced imaging technique such as MRI. Third, the cross-sectional design did not allow us to measure the natural history of this US finding and its clinical relevance. In conclusion, this pilot study provides evidence of the focal thickening of the hyaline cartilage above an osteophyte. Further research is needed to confirm our preliminary results in a larger cohort of patients with hand OA, to clarify if cartilage thickening occurs in specific areas of the joint and/or in specific phases of the disease, and to investigate its clinical relevance.

#### Abbreviations

CR	Conventional Radiography
EULAR	European Alliance of Associations for Rheumatology
HCT	Hyaline Cartilage Thickness
JSN	Joint Space Narrowing
KLS	Kellgren-Lawrence Score
MCP	Metacarpophalangeal
MRI	Magnetic Resonance Imaging
OA	Osteoarthritis
OMERACT	Outcome Measure in Rheumatology
SQ	Semiquantitative
STROBE	Strengthening the Reporting of Observational Studies in
	Epidemiology
US	Ultrasonography

# **Supplementary Information**

The online version contains supplementary material available at https://doi.or g/10.1186/s41927-025-00473-3.

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Supplementary Material 1
Supplementary Material 2
Supplementary Material 3
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#### Author contributions

Study conception and design. EC EF. Acquisition of data. EC RMM GS EF. Analysis and interpretation of data. EC RMM GS EF PM. Statistical analysis. EC. All authors have drafted the article, revised it critically for important intellectual content and read and approved the final version of the manuscript.

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#### Data availability

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

# Declarations

#### Ethics approval and consent to participate

The study protocol was approved by the local ethics committee (id CERM: 262/2019) of the Comitato Etico Unico Regione Marche. Patients have signed their consent to participate in the study.

### **Consent for publication**

Not applicable.

#### Declaration of generative AI in scientific writing

The authors declare that they have not used any type of generative artificial intelligence for the writing of this manuscript, nor for the creation of images, graphics, tables, or their corresponding captions.

## **Competing interests**

EC has received research grant from FOREUM and EULAR, speaking fees from IBSA, and Novartis, outside the submitted work. EF has received speaking fees from AbbVie, Bristol-Myers Squibb, Celgene, Novartis, Pfizer, Roche and Union Chimique Belge Pharma, outside the submitted work. PM has received speaking fees from AbbVie, Janssen, Novartis and Sobi, and grant support by AbbVie, Alfasigma, Novartis and UCB. All other authors have declared no conflict of interest.

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