Prevalence and distribution of cartilage and bone damage at metacarpal head in healthy subjects

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Abstract

Objective

To determine the prevalence and distribution of the ultrasound (US) findings indicating cartilage and bone damage at the metacarpal head (MH) in a group of healthy subjects (HS), and their association with the clinical and US data. We also aimed to provide standard reference values of cartilage thickness.

Methods

US scans of the dorsal aspect of the metacarpophalangeal joints (MCPj) from 2nd to 5th finger of both hands were performed in 179 HS. The presence of cartilage damage, osteophytes and bone erosions was recorded.

Results

Cartilage damage, osteophytes and bone erosions were found in at least one MCPj in 30 (16.8%), 17 (9.5%) and 4 (2.2%) out of 179 HS, respectively. Signs of cartilage damage were found in 91 out of 1432 MHs (6.4%). Blurring of the chondrosynovial margin, minimal and severe thinning were detected in 73.7%, 26.3% and 0% of the 91 MHs, respectively. Osteophytes and bone erosions were found in 31 (2.2%) and in 4 (0.3%) MCPjs. The thickness of the MH cartilage ranged between 0.41 and 1.10 mm in males and between 0.36 and 1.03 mm in females. A significant association was found between cartilage thickness and age ($r=-0.33$, $p<0.001$), sex ($r_{pb}=0.42$, $p<0.001$), height ($r=0.39$, $p<0.001$) and osteophytes in the same joint ($v=-0.54$, $p<0.001$) and between working condition and osteophytes ($v=0.31$, $p=0.021$).

Conclusion

This cross-sectional study reports the prevalence of US findings of joint damage in a large cohort of HS. Moreover, standard reference values of the MH cartilage thickness in HS are provided.

Key words

hyaline cartilage, metacarpophalangeal joint, ultrasonography, rheumatoid arthritis, osteoarthritis

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Introduction

Cartilage damage is one of the most relevant factors in determining loss of joint function and irreversible physical disability in patients with degenerative and inflammatory arthropathies (1-8). As well as bone erosions, cartilage damage is an imaging biomarker of joint damage and disease severity in patients with rheumatoid arthritis (RA) and osteoarthritis (OA). Therefore, special attention should be paid to detect cartilage damage as its early recognition might guide therapeutic management, including a more aggressive treatment approach (9).

A growing body of evidence has shown that ultrasound (US) may be able to detect signs of structural damage (*i.e.* bone erosions) at an earlier stage in comparison with conventional radiography in such patients (10-15). The potential value of US in the identification of bone erosions in patients with RA (especially in early disease) has also been acknowledged in the European League Against Rheumatism (EULAR) recommendations for the use of imaging in the clinical management of RA (16). On the other hand, US is not routinely recommended in the assessment of cartilage pathology in both RA and OA (16, 17). Only recently, the Outcome Measure in Rheumatology (OMERACT) US Group has proposed definitions for cartilage damage in RA and OA (18-21). According to these definitions, blurring of the outer and/or the subchondral margin under orthogonal insonation, focal or diffuse thinning of the hyaline cartilage, and incomplete or complete loss of homogeneity of the echostructure, should be regarded as US findings indicative of cartilage damage (18, 19).

Although an expert-based agreement on US definitions of cartilage damage has been obtained, still more investigation is required to further validate these definitions in a "real life" setting and to collect information about the spectrum of cartilage abnormalities in healthy subjects (HS). To the best of our knowledge, only one study examined the validity of US in the evaluation of cartilage damage using the novel OMERACT definitions in a cohort of 103 RA patients and 42 HS (22).

Therefore, the main aim of this study was to determine the prevalence and distribution of US findings indicative of cartilage and bone damage (*i.e.* bone erosions and osteophytes) at metacarpal heads level in a group of HS. Secondary aims were i) to assess the association between cartilage and bone damage and clinical, laboratory and sonographic data; ii) to provide standard reference values of the metacarpal head cartilage thickness in HS.

Materials and methods

Subjects

HS were consecutively recruited among: staff members of the Carlo Urbani Hospital (Jesi, Ancona, Italy), medical students attending the Rheumatology Unit, and healthy relatives visiting or accompanying patients.

Exclusion criteria were: i) history of inflammatory or degenerative arthropathy, ii) history of relevant trauma or surgery at hand level, iii) joint pain [visual analogue scale (VAS) ≥10/100] in the month preceding the enrolment, iv) hands synovitis or tenosynovitis on physical examination, v) clinically detectable hard tissue enlargement or deformity of the metacarpophalangeal (MCP), proximal or distal interphalangeal joints suggestive of hand OA, vi) analgesic and/or non-steroidal anti-inflammatory drugs intake in the month preceding the visit, vii) age <18 years old or >65 years old. Subjects aged 66 years or older were excluded *a priori* due to the high prevalence of joint abnormalities (*i.e.* osteophytes and bone erosions) (23).

All subjects gave their written informed consent. The study was conducted in accordance with the Declaration of Helsinki.

Clinical examination

A rheumatologist performed the physical examination in all the subjects. For each subject, the following data were collected: age, gender, height, weight, dominant hand, professional occupation, joint pain in the hands (0–100 VAS pain), and drug intake in the month preceding the visit.

Scanning protocol

The US assessment was performed by a

Table I. Demographic characteristics of healthy subjects.

	All HS n=179	Group 1 (18-30 years) n=66	Group 2 (31-45 years) n=49	Group 3 (46-65 years) n=64
Age (years)	35.7 ± 12.98	22.88 ± 1.71	37.27 ± 4.67	52.8 ± 5.68
Sex (F/M)	97/82	25/41	30/19	42/22
Height (m)	1.71 ± 0.09	1.75 ± 0.09	1.70 ± 0.09	1.69 ± 0.09
Weight (kg)	73.02 ± 14.78	66.82 ± 8.96	73.27 ± 19.03	78.07 ± 14.21
BMI (kg/m^2)	24.69 ± 5.09	21.82 ± 1.74	25.25 ± 6.13	27.36 ± 5.33
Handedness (R/L)	142/18	57/9	42/7	61/3
Occupation				
White-collar job	31 (17.3)	12 (6.7)	7 (3.9)	14 (7.8)
Blue-collar job	66 (36.9)	9 (5.0)	39 (21.8)	18 (10.1)
Other	80 (44.7)	45 (25.1)	3 (1.7)	32 (17.9)

BMI: body mass index; F: female; HS: healthy subjects; L: left; M: male; other: unemployed, retired, student; R: right. Values in brackets are percentages.

sonographer with 4 years of experience in musculoskeletal US (E.C.), whose inter- and intra-observer agreement was tested in a previous study and was reported as moderate-to-substantial in comparison with an expert sonographer (E.F.) (24).

The US scans were carried out using a MyLab Class C US system (Esaote SpA, Genoa - Italy), employing a 10–22 MHz and a 6–18 MHz broadband linear probes. The presence of US pathological findings was explored in the MCP joints (from the 2nd MCP joint to the 5th MCP joint), bilaterally. The images were acquired according to the 2017 EULAR standardised procedures for US imaging in rheumatology with longitudinal and transverse scans (25).

Cartilage damage

The US pathological findings of cartilage damage were initially described in the nineties (26, 27), and subsequently variably combined in the OMERACT definitions (18-20).

According to these definitions, US elementary lesions indicative for cartilage damage were identified as follows:

- blurring of the outer margin and/or the subchondral margin under orthogonal insonation;
- focal or diffuse thinning of the hyaline cartilage layer;
- incomplete or complete loss of homogeneity of the cartilage echostructure.

The hyaline cartilage of the metacarpal head was scanned on the dorsal aspect of the MCP joints, with the joint flexed more than 60 degrees (closed fist). To ensure the perpendicular insonation of the cartilage layer, particular attention was paid to visualise a sharp and bright osteochondral margin and, whenever possible, to obtain a sharp and bright chondrosynovial interface (24, 28, 29). In addition, to differentiate between the chondrosynovial margin and other hyperechoic interfaces, a dynamic assessment of the metacarpal head was performed.

Qualitative assessment of the metacarpal head's cartilage was made on the basis of a multiplanar and dynamic examination and it was performed using a three-grade scoring system (18): grade 0, normal cartilage; grade 1, minimal change: focal thinning or incomplete loss of cartilage; grade 2, severe change: diffuse thinning or complete loss of cartilage. Moreover, the presence/absence of blurring of the chondrosynovial margin under orthogonal insonation was noted.

Quantitative measurements of metacarpal head's cartilage thickness were taken on static images which were acquired using the dorsal longitudinal and the dorsal transverse (acquired rotating the probe 90° from the dorsal longitudinal view) scans of the hyaline cartilage (24). Since the cartilage thickness over the entire metacarpal head may not be the same, the measurements were taken in the central third of the metacarpal head's cartilage (the force-bearing portion) to increase reproducibility (24). The chondrosynovial margin of the hyaline cartilage was included in the measurement (24, 28, 29). In the absence of an evident superficial cartilage margin, the largest distance of anechoic or hypoechoic tissue was measured perpendicularly to the bone surface (30). The average value of the dorsal longitudinal and transverse metacarpal head's cartilage thickness measurements was calculated. The cartilage thickness measurements were not corrected for the higher speed of sound in hyaline cartilage as compared to soft tissues, since the measurements were not correlated with histological or other imaging measurements (18).

To evaluate US features of the hyaline cartilage, the grey-scale setting parameters were set as follows: B-mode frequency: 22 MHz, master gain: 70%, mechanical index: 0.3, dynamic range: 12, depth 15 mm, focus position at the area of interest.

Table II. Ultrasound scores of the cartilage thickness in healthy subjects.

	All HS (n=179)	Group 1 (18-30 years) n=66	Group 2 (31-45 years) n=49	*p*-value (1-2)	Group 3 (46-65 years) n=64	*p*-value (1-3)	*p*-value (2-3)
Dominant hand score	2.53 ± 0.34	2.66 ± 0.32	2.42 ± 0.32	<0.001	2.44 ± 0.31	<0.001	0.785
Non-dominant hand score	2.57 ± 0.38	2.72 ± 0.36	2.49 ± 0.35	<0.001	2.44 ± 0.36	<0.001	0.701
Subject score	5.09 ± 0.70	5.38 ± 0.67	4.90 ± 0.64	<0.001	4.87 ± 0.66	<0.001	0.257

HS: healthy subjects. Results are expressed in millimeters as mean ± standard deviation. The subject score is the result of the sum of both sides. *p*-value refers to the t-test aimed at comparing different groups.

Bone erosions and osteophytes
Bone erosions and osteophytes were identified, according to the OMERACT definitions, as follows:
- osteophytes: step-up bony prominences at the bony margin that is visible in two perpendicular planes (19);
- bone erosions: intra- and/or extra-articular discontinuities of bone surface (visible in two perpendicular planes) (19).

Osteophytes and bone erosions were investigated using a 6-18 MHz transducer with the subject's hands in neutral position. The dorsal aspect from the 2nd MCP joint to the 5th MCP joint was evaluated on longitudinal and transverse views, and the 2nd and 5th metacarpal heads were also assessed using lateral scans. Previously described semiquantitative scoring systems for osteophytes (0=none, 1=minor, 2=moderate, 3=major size of osteophytes) and bone erosions (grade 0: no erosion; grade 1: <1 mm, grade 2: 1 to <2 mm; grade 3: 2 to ≤3 mm; grade 4: >3 mm; grade 5: multiple bone erosions) were adopted (10, 31).

Statistical analysis
Results are expressed as number and/or percentage for qualitative variables and as mean and standard deviation (SD) and/or the 95% confidence interval (95%CI) for quantitative variables. Quantitative variables were checked for normality using Shapiro-Wilk test. The Mann-Whitney test and Student t-test were used to compare the quantitative variables and the Chi-Square test to compare the qualitative variables.
Subjects were stratified according to their age in three groups: age group 1 (18–30 years old), age group 2 (31–45 years old) and age group 3 (46–65 years old).
Because hyaline cartilage's thickness in a single metacarpal head may not be representative of the cartilage status at subject level, several US scores, that were sum of multiple cartilage thickness measurements, were calculated: subject score (sum of the cartilage thickness values acquired from second to fifth metacarpal heads of both hands), non-dominant hand score (sum of the cartilage thickness values acquired in the 4 examined metacarpal heads of the non-dominant hand), dominant hand score (sum of the cartilage thickness values acquired in the 4 examined metacarpal heads of the dominant hand). If data were missing for any joint used to calculate a score, the subject was excluded.
The association between the US findings and clinical parameters was explored. The Point-Biserial correlation (r_{pb}) was used to evaluate the association between the US scores and the qualitative variables, whereas the Spearman's rank correlation was used to correlate the US findings with the quantitative variables. Chi-square test and Cramer's v were used to correlate US findings (*i.e.* cartilage damage) with the categorical and/or ordinal variables (*i.e.* presence of osteophytes and bone erosions).
Two tailed *p*-values less than 0.05 were considered significant. Statistical analysis was performed using SPSS (Statistical Package for the Social Sciences) software (v. 25.0, Chicago, Illinois, USA).

Results
Two hundred and seven subjects were initially assessed. Of these, 28 (13.5%) were subsequently excluded from the study because meeting the exclusion

Table III. Multiple linear regression predicting ultrasound cartilage thickness in healthy subjects.

	Unstandardised coefficient		Standardised coefficient	Significance	95% CI	
	Beta	SE	Beta	*p*-value	Lower Limit	Upper Limit
(constant)	3.27	1.27			0.77	5.78
Age	-0.01	0.00	-0.21	<0.001	-0.02	0.00
Height	1.51	0.74	0.18	0.040	0.05	2.97
Sex	0.39	0.13	0.26	<0.001	0.13	0.66

R^2: 0.25; Adjusted R^2: 0.24. Subject score = 3.27 - 0.01*Age + 1.51*Height + 0.39 (if male).
Dependent variable: subject score. 95%CI: 95% confidence interval; SE: standard error.

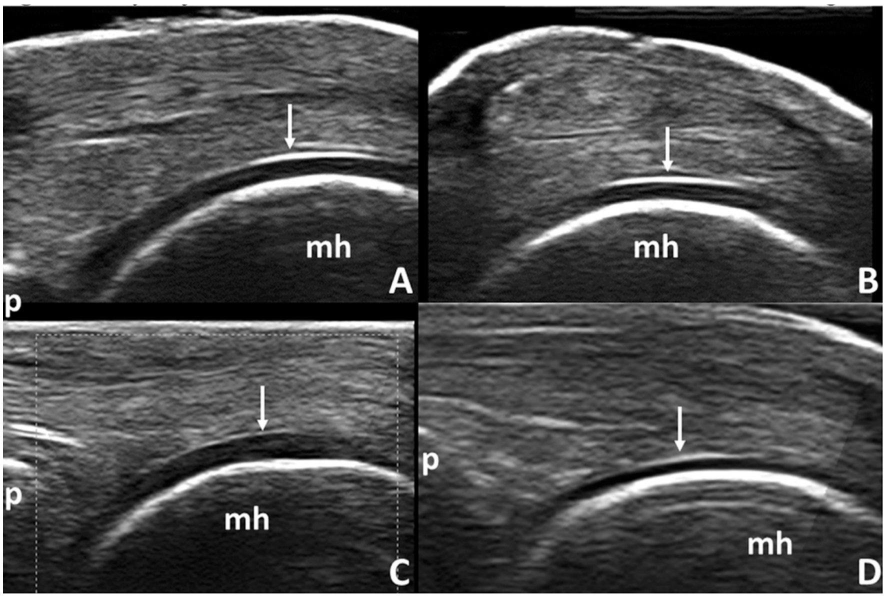

Fig. 1. Healthy subjects. Pictorial evidence of ultrasound normal and abnormal cartilage.
A and **B**: dorsal longitudinal and transverse scans of the metacarpal head. Normal appearance of hyaline cartilage.
C: dorsal longitudinal scan of the metacarpal head. Loss of sharpness of the chondrosynovial margin of the hyaline cartilage.
D: dorsal longitudinal scan of the metacarpal head. Minimal changes of the hyaline cartilage: partial thinning of cartilaginous layer (OMERACT grade 1).
Arrows: chondrosynovial interface, **mh:** metacarpal head, **p:** phalanx.

Table IV. Cartilage thickness measurements: dominant-non-dominant comparison.

	Dominant		Non-dominant		Mean difference	*p*-value
	Mean	SD	Mean	SD		
2nd MH	0.69	0.09	0.69	0.09	<0.01	0.745
3rd MH	0.62	0.10	0.63	0.10	0.01	0.310
4th MH	0.61	0.09	0.60	0.10	0.01	0.845
5th MH	0.62	0.10	0.64	0.12	0.02	0.120

MH: metacarpal head; SD: standard deviation. The results are expressed in millimeters.

Table V. Cartilage thickness measurements in males and females.

	Males (n=656)		Females (n=776)		Mean difference	*p*-value
	Mean	SD	Mean	SD		
2nd MH	0.72	0.09	0.66	0.10	0.06	<0.001
3rd MH	0.66	0.08	0.58	0.09	0.08	<0.001
4th MH	0.65	0.08	0.57	0.09	0.08	<0.001
5th MH	0.68	0.10	0.60	0.11	0.08	<0.001

MH: metacarpal head; n: number of healthy metacarpal heads; SD: standard deviation.
The results are expressed in millimetres.

criteria [*i.e.* joint pain in the month preceding the visit (0–100 VAS pain >1/10) in 16 subjects and signs of hand osteoarthritis on physical examination in 12 subjects].
The final analysis included 179 HS and 1432 metacarpal heads. Table I shows the main demographic data of the HS.

US assessment of cartilage at subject level

One or more US findings indicative of cartilage damage were found in at least one metacarpal head in 30 (16.8%) HS. Table II reports the mean values of the cartilage thickness scores. Males had a significantly thicker hyaline cartilage than females (subject score in males: 5.40±0.60 mm; subject score in females: 4.81±0.66 mm; mean difference: 0.59 mm; $p<0.001$), both in the dominant hand (dominant score in males: 2.68±0.28 mm; dominant score in females: 2.38±0.31 mm; mean difference: 0.30 mm; $p<0.001$) and in the non-dominant hand (non-dominant score in males: 2.72±0.34 mm; non-dominant score in females: 2.43±0.36 mm; mean difference: 0.29 mm; $p<0.001$).
A significant positive association between cartilage thickness (subject score) and height (r=0.39, $p<0.001$) and sex ($r_{pb}=0.42$, $p<0.001$) was found, while a significant negative correlation between cartilage thickness and age (r=-0.33, p<0.001) was detected. Occupation ($p=0.07$), weight ($p=0.34$), BMI ($p=0.08$) and handedness ($p=0.43$) were not significantly correlated with cartilage thickness. The linear regression analyses confirmed these data. In fact, age (ß=-0.21, $p<0.001$), height (ß=0.18, $p=0.040$), and sex (ß=0.26, $p<0.001$) were predictive of the US subject score (Table III).

US assessment of cartilage at joint level

US abnormalities indicative of cartilage damage were detected in 91 (6.4%) out of the 1432 examined metacarpal heads.
According to the qualitative evaluation of cartilage abnormalities, 67 (73.7%) metacarpal heads presented a blurring of the chondrosynovial margin, 24 (26.3%) were scored as grade 1 and 0 as grade 2. Figure 1 provides a pictorial evidence of US normal and abnormal cartilage in HS.
Cartilage thickness of metacarpal heads ranged between 0.41 and 1.10 mm in male HS and between 0.36 and 1.03 in female HS. No significant difference was found between dominant and non-dominant sides for each metacarpal head (Table IV).
A significantly thicker cartilage was found in males than in females in all the metacarpal heads (Table V).
A weak association between cartilage damage and age was reported (v=0.17, $p<0.001$); cartilage damage was found in 6 (1.2%), 33 (8.3%) and 52 (10.2%) metacarpal heads of age group 1, 2 and 3, respectively. A moderate association between cartilage damage and osteophytes was found (v=0.54, $p<0.001$); in fact, osteophytes were detected in 16 (1.2%) and 15 (62.5%) metacarpal heads scored as grade 0 and grade 1, respectively. No association was found between the presence of cartilage damage and bone erosions ($p=0.915$).

Standard reference values of hyaline cartilage thickness

Standard reference values of the hyaline cartilage's thickness were obtained in a total of 1341 metacarpal heads (the 91 joints with abnormal qualitative findings were excluded from the analysis). Detailed description of cartilage thickness was reported in Table VI.
Overall, the hyaline cartilage of the 2nd metacarpal head was thicker than the hyaline cartilage of the other metacarpal heads [mean differences (2nd-3rd): 0.07 mm; $p<0.001$, (2nd-4th): 0.10 mm; $p<0.001$, (2nd-5th): 0.06 mm; $p<0.001$]. No difference was found between the cartilage thickness of the other metacarpal heads.
The average absolute difference of the cartilage thickness between right and left side was 0.05±0.04 mm (95%CI: 0.01–0.14 mm).
The average absolute difference of the cartilage thickness measurements between longitudinal and transverse scans was 0.03±0.03 mm (95%CI: 0.00–0.09 mm).

US assessment of osteophytes and bone erosions

Osteophytes and bone erosions were detected in 17 (9.5%) and 4 (2.2%) HS and in 31 (2.2%) and 4 (0.3%) MCP joints, respectively.
Twenty-six (83.9%) out of 31 osteophytes were found on the dorsal aspect of the metacarpal head, and only 5 (16.1%) on the lateral aspect. Fifteen (48.4%) out of 31 osteophytes were found together with cartilage abnormalities. Twenty-nine (93.5%) osteophytes were scored as grade 1 and 2 (6.5%)

Table VI. Standard reference values of metacarpal head cartilage thickness.

		Group 1 (18-30 years) n=66			Group 2 (31-45 years) n=49			Group 3 (46-65 years) n=64		
		Mean	SD	95%CI	Mean	SD	95%CI	Mean	SD	95%CI
Males	2nd MH	0.73	0.09	0.92-0.54	0.73	0.08	0.90-0.56	0.69	0.08	0.86-0.53
	3rd MH	0.68	0.08	0.83-0.53	0.67	0.10	0.87-0.47	0.63	0.08	0.78-0.47
	4th MH	0.65	0.09	0.82-0.47	0.64	0.08	0.80-0.48	0.63	0.08	0.80-0.47
	5th MH	0.70	0.10	0.90-0.56	0.67	0.10	0.86-0.48	0.65	0.07	0.80-0.50
	SUM	6.08	0.65	7.38-4.79	5.97	0.66	7.28-4.65	5.78	0.54	6.85-4.70
Females	2nd MH	0.70	0.10	0.90-0.50	0.65	0.08	0.81-0.50	0.64	0.10	0.85-0.43
	3rd MH	0.64	0.10	0.84-0.45	0.54	0.07	0.67-0.41	0.57	0.08	0.73-0.41
	4th MH	0.62	0.11	0.84-0.40	0.53	0.07	0.66-0.40	0.57	0.09	0.75-0.39
	5th MH	0.63	0.11	0.85-0.41	0.59	0.10	0.59-0.39	0.57	0.11	0.78-0.35
	SUM	5.61	0.61	6.83-4.39	5.12	0.54	6.19-4.04	5.13	0.69	6.51-3.75

95%CI: 95% confidence interval; MH: metacarpal head; SD: standard deviation.
Results are expressed in millimetres.

as grade 2. A positive correlation was found between the presence of osteophytes and age (r_{pb} =0.13, p<0.001). In fact, 1 (0.2%) osteophyte was found in 1 subject (1.5%) of age group 1 (18–30 years old), 12 (3.1%) osteophytes in 6 subjects (12.2%) of age group 2 (31–45 years old) and 18 (3.5%) osteophytes in 10 subjects (15.6%) of age group 3 (46–65 years old). Grade 2 osteophytes were reported only in age group 3. A significant association between occupational status (subjects with blue-collar job) and osteophytes was reported (v=0.31, p=0.021).

Bone erosions were found only in the lateral aspect of the metacarpal head. One (25.0%) out of 4 bone erosions was found associated with cartilage abnormalities. All bone erosions were smaller than 1 mm (grade 1). One bone erosion was detected in a subject of age group 2, while 3 bone erosions were found in 3 subjects of age group 3. No bone erosions were reported in subjects of age group 1.

The prevalence of osteophytes and bone erosions was similar in dominant and non-dominant side. In addition, the prevalence of bone erosions was not significantly different in subjects with white- and blue-collar jobs (p=0.56).

Discussion

To the best of our knowledge, this is the first study aimed at assessing the prevalence of US findings indicative of cartilage damage in a large cohort of HS. A few studies have investigated the metacarpal head's cartilage in HS, all including a small sample size (22, 27, 29, 30). None of these studies was conducted using a very high-frequency probe with an axial resolution smaller than 0.10 mm, thus limiting the ability of US to detect even minimal abnormalities of the hyaline cartilage.

The most relevant results of our study can be summarised as follows:

- the prevalence of cartilage abnormalities was relatively low at joint level (6.4%), whereas it was notable at the subject level (16.8%);
- the blurring of the outer margin was the most frequently detected US findings (73.7% of the 91 metacarpal heads with cartilage abnormalities), while definite cartilage thinning was found in 26.3% of the 91 metacarpal heads with cartilage abnormalities;
- US signs of cartilage damage were frequently found in association with osteophytes (1.2% of metacarpal heads with normal cartilage *versus* 62.5% of metacarpal heads presenting a grade 1 of cartilage damage);
- no difference of the hyaline cartilage's thickness was found between the metacarpal heads of dominant and non-dominant hand;
- the hyaline cartilage of the 2nd metacarpal head was significantly thicker than the hyaline cartilage of the other metacarpal heads.

Our findings prompt the following observations. First, cartilage thinning might represent the most specific US biomarker of cartilage pathology as it was the US finding with the lowest prevalence in our group of HS. On the other hand, the blurring of the outer margin may be not specific enough for identifying cartilage damage. As previously reported (18, 22, 32, 33), this pathological finding can be found in patients with subclinical diseases (such as pre-symptomatic phases of hand osteoarthritis) and/or with previous joint trauma or biomechanical overload, thus it does not necessarily represent "true" cartilage damage. Second, when assessing hyaline cartilage, right-left comparison may be used to confirm a cartilage damage, while the comparison between the 2nd metacarpal head and the other metacarpal heads should consider the physiological difference of the hyaline cartilage's thickness. Finally, the data acquired in the present study can be used as standard reference values of metacarpal head's cartilage thickness.

This is the first study which proposed standard reference values of hyaline cartilage's thickness. The identification of such values may allow for a better assessment of cartilage involvement in inflammatory and degenerative arthropathies. A metacarpal head's cartilage thinner than the 95%CI lower bound of the standard reference values (Table VI) and/or a difference in the side-by-side comparison greater than the 95%CI upper bound of the absolute mean difference (0.14 mm) may be highly indicative of cartilage thinning. However, these values must be fully validated in further studies involving both RA and OA patients and HS.

As previously reported by Möller *et al*. (30), we found a significant correlation between the US score of cartilage thickness and sex, age and height. Using age group 1 (18–30 years old) as reference, HS in the other age groups had a significant thinner cartilage. The difference in thickness of the cartilage layer was less pronounced between age group 2 and 3 and it did not reach statistical significance.

Only few US studies investigated the prevalence of osteophytes and bone erosions in healthy MCP joints (13, 34-40). In our cohort of HS, US allowed the detection of osteophytes and bone erosions, especially in subjects older than 30 years old. In a recent CT study, Berlin *et al*. reported a significant increase with age of osteophytes and erosive changes in MCP joints (23). Fodor *et al*. enrolled 50 HS and reported the presence of at least one osteophyte in 8.0% of them; osteophytes were found only in subjects older than 50 years old and only in the dorsal view (34). We documented a slightly higher prevalence of osteophytes (9.5%); moreover, osteophytes were found also in subjects between 30 and 45 years old, especially in those with a blue-collar job.

The prevalence of bone erosions in our study is in line with previous works on HS (13, 34, 37-40) showing a prevalence of bone erosions ranging from 0% to 18% of the subjects. Several explanations were proposed to address this variability: a small sample size in the majority of these studies, different demographic characteristics (*e.g*. age and occupational status), the use of different US equipment (*e.g*. 10 *vs*. 18 MHz probes) and a different number of anatomical areas explored by US. Nevertheless, in the largest studies conducted by Schmidt *et al*. and Padovano *et al*. on 103 and 207 HS, respectively, no bone erosions were reported at MCP joints (37, 40). As previously reported, US bone erosions in HS were characterised by the small size of the erosive crater (<2 mm), the absence of Doppler signal inside the erosion and the fact that bone erosions were usually detected as an isolated pathologic finding (13, 37). In our cohort, we documented a low prevalence of bone erosions (2.2% of HS) and only in subjects older than 40 years old, as reported by Fodor *et al*. (34)

The main limitation of the study is represented by the monocentric design and the absence of an across-operator reproducibility analysis of the US examinations as they were performed by a single sonographer.

Further investigations, including patients with RA and OA, are needed to explore the diagnostic accuracy of the proposed cut-off values of cartilage thickness and to test the validity of the latest OMERACT definitions (18-20).

In conclusion, our study showed that US findings of cartilage damage may be detected in up to 16.8% of HS. These data may help to interpret metacarpal head cartilage pathology suggesting qualitative and quantitative cut-off values for distinguishing normal and abnormal cartilage, and may contribute to improve the OMERACT definitions of cartilage involvement in RA and OA.

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