The minimal erosive volume needed for radiographic identification of erosions in the metacarpophalangeal joints in patients with rheumatoid arthritis.

Running title

Erosive MCP

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CONFLICTS OF INTEREST

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KEYWORDS

Computed Tomography; Rheumatoid arthritis; Joint erosions; Metacarpophalangeal joint; Radiography.

ETHICAL APPROVAL

The Ethics Committee of Medical Research in Central Denmark Region(1-10-72-437-17) and the Danish Data Protection Agency(1-16-02-33-18) approved the study. The study was registered at ClinicalTrials.gov(NCT03429426). All patients gave informed written consent before inclusion, and the study was performed in agreement with the Declaration of Helsinki.

ABSTRACT

OBJECTIVE

To compare in images obtained by High-Resolution peripheral Quantitative Computed Tomography(HR-pQCT) and conventional radiography(CR) of the second and third metacarpophalangeal(MCP) joints the minimal erosive cortical break needed to differentate between pathological and physiological cortical breaks.

METHODS

In this single-centre cross-sectional study, patients with established RA(disease duration ≥ 5 years) had their second and third MCP joints of the dominant hand investigated by HR-pQCT and CR. Empirical estimation was used to find the optimal cutoff value for the number of erosions and total erosive volume, which were detectable between patients with and without erosions in the second and third MCP joints according to CR.

RESULTS

The total erosive volume in the second and third MCP joints by HR-pQCT for CR detected erosive disease was estimated to be 56.4(95% CI: 3.5 – 109.3) mm^3. The sensitivity and specificity at this cutpoint were 78% and 83%, with an area under the receiver operating characteristic curve(AUC) of 0.81. The optimal cutoff value for the number of erosions by HR-pQCT was 8.5(95% CI:5.9 – 11.1) for CR detected erosive disease in the second and third MCP joints by CR. The sensitivity and specificity at this cutpoint were 74% and 88%, respectively, with an AUC of 0.81.

CONCLUSION

Erosions by HR-pQCT were larger in patients with erosive damage in the second and third MCP joints by CR. We found that CR had poor sensitivity for detecting erosive disease when the erosive volume was less than 56.4 mm^3 or the number of erosions less than 8.5.

INTRODUCTION

Erosive damage is a cardinal sign of rheumatoid arthritis(RA) and is correlated with disease activity[1]. Conventional radiography(CR) of the hands, wrist and feet is currently the gold standard for evaluating the radiographic disease severity of RA[2,3] . The radiographic examinations are most commonly assessed by the Sharp/van der Heijde(SHS) score in observational and clinical trials[2,3] as this method is the most reliable and sensitive method for tracking the progression of radiographic damage[4]. However, as the treatment of patients with RA has improved, CR is no longer sensitive enough to detect the progression of discrete erosive damage.

Imaging by High-Resolution peripheral Quantitative Computed Tomography(HR-pQCT) has been proposed as a modality for assessing erosive cortical breaks in patients with RA because of its high resolution and three-dimensional imaging[5]. A previous study found that HR-pQCT imaging of the second and third metacarpophalangeal(MCP) joints from one hand, and CR of hands, wrist and feet had comparable diagnostic accuracy for diagnosing RA patients having erosive disease[6].

The objective of the present study was to evaluate the volume and number of erosive cortical breaks on HR-pQCT of the second and third MCP joints needed to be optimally detectable by CR.

METHOD

STUDY DESIGN

We used data from the RACTX cohort for this cross-sectional single-centre study, which consisted of 354 patients with established RA(disease duration ≥ 5 years)[6]. HR-pQCT, and CR investigated the second and third metacarpophalangeal(MCP) joints from one hand. The study was designed following the Strengthening the Reporting of Observational Studies in Epidemiology(STROBE) guideline[7].

PATIENT AND PUBLIC INVOLVEMENT STATEMENT

We investigated the presence of erosive disease in patients with RA by two different imaging modalities in the current study. Therefore, we did not involve patients regarding the study design, outcome, or recruitment.

PARTICIPANTS

Patients with RA were recruited from the outpatient clinic at the Department of Rheumatology, Aarhus University Hospital. The inclusion period was between March 2018 and October 2020. The patients were examined by HR-pQCT and CR, which were conducted within three months of each other. A full medical history was obtained, and a clinical examination was performed for all individuals. Specifically, demographic and clinical data were acquired, including age, gender, disease duration, number of tender and swollen joints, C-reactive protein(CRP), health assessment questionnaire(HAQ), as well as anti-citrullinated protein antibodies(ACPA) and immunoglobulin M Rheumatoid Factor(RF).

ELIGIBILITY CRITERIA

Inclusion criteria were diagnosed RA, according to the ACR/EULAR(2010) classification criteria[8], disease duration ≥ 5 years, the ability to give informed consent, and age ≥ 18 years. Exclusion criteria were fracture, luxation or prosthesis of the MCP joints in both hands, evidence of active malignant disease, hypocalcemia, impaired renal function(eGFR <35ml/min), untreated hypo- or hyperthyroidism, or pregnancy.

CONVENTIONAL RADIOGRAPHY ACQUISITION AND SCORING

All patients had their hands, wrist and feet examined radiographically using the standard dorsopalmar(PA) projection. The image was generated at a focus distance of 100-115 cm, 50-55 kV and 2-12 mAs. The radiographs were scored by a single trained reader(RKJ) using the Sharp/van der Heijde score system(SHS)[3].

HR-PQCT ACQUISITION AND ANALYSIS

An image acquisition protocol endorsed by the Study grouP for xtrEme-Computed Tomography in Rheumatoid Arthritis(SPECTRA) was used[9]. The second and third MCP joints were imaged using the first-generation XtremeCT scanner(Scanco Medical, Brüttiselen, Switzerland). A 2.7-cm-long volume of interest(VOI) was scanned with a spatial resolution of 82 μm^3, an X-ray tube voltage of 59.4 kVp, a current of 900 µA, and an integration time of 100 ms. The scan was performed within a region of 80 slices(6.56 mm) distal and 250 slices(20.5 mm) proximal to the distal end of the third metacarpal head. The dominant hand was scanned except in cases with prior fracture, prosthesis or luxation in the MCP joints. Digital Imaging and Communications in Medicine(DICOM) images were exported from the HR-pQCT scanner and evaluated by OsiriX medical imaging

software(Version 9.0.1; Pixmeo, Bernex, Switzerland) on a 27-inch cinema screen iMac. Each image was anonymised before analysis. The quality of each scan was evaluated as previously described[10,11]. Each joint was divided into the proximal end(metacarpal head) and the distal end(proximal phalanx). Each bone was divided into four quadrants(dorsal, radial, palmar and ulnar)[12]. Each quadrant was then evaluated for the presence of erosive cortical breaks by two experienced readers(RKJ, JB).

Each erosion was measured according to the maximal width, depth and length. The volume of each erosion was measured by manual segmentation using OsiriX medical imaging software[6]. The erosion volume was also calculated as a half-ellipsoid from the measured width, depth, and length[13]. The erosions were defined according to the SPECTRA definition[14]. *In brief: A definite cortical break in two consecutive slices, in at least two perpendicular planes, and with underlying loss of trabecular structure. Lastly, the cortical break had to be nonlinear to differentiate between erosive cortical breaks and physiological cortical breaks, i.e., vascular channels*[15]. The erosions were measured according to the maximal width, depth, length, and volume.

Ethical approval

The Ethics Committee of Medical Research in Central Denmark Region(1-10-72-437-17) and the Danish Data Protection Agency(1-16-02-33-18) approved the study. The study was registered at ClinicalTrials.gov(NCT03429426). All patients gave informed written consent before inclusion, and the study was performed in agreement with the Declaration of Helsinki.

SAMPLE SIZE

Previously, only a few smaller studies have investigated erosions by HR-pQCT in patients with erosive and non-erosive MCP joints by CR. However, these studies did not assess erosive damage by the SHS score, and did not assess the volume of erosions manually[16,17]. Therefore, no data is available on the relevant populations which can be used to perform sample size calculations. Still, our study includes the largest patient cohort presently for any study investigating erosive cortical breaks by HR-pQCT in inflammatory rheumatic disease, and the included number of patients is assessed sufficiently to fulfil our aim[5].

STATISTICAL METHODS

Data were analysed using STATA 13(StataCorp LP, College Station, TX, USA). The normality of the data distribution was investigated with Q-Q plots and histograms. As the data were non-normally distributed, data were presented as median(IQR), and statistical significance was tested using the Mann-Whitney U test. The intrareader reliability was investigated by intraclass correlation coefficient(ICC) for 10% of the CR and HR-pQCT scans by a single trained reader(RKJ). The interreader reliability was investigated for 10% of the CR images by two trained readers(RKJ, JT). The interreader reliability was investigated for 50% of the HR-pQCT images by two trained readers(RKJ, JB). Correlations were calculated by Spearman's rank correlation coefficient(ρ). The measured volume in Osirix and calculated half-ellipsoid volume were compared for each cortical interruption by Bland-Altman plots[18]. We assessed optimal cutoff values for the number and total volume of erosions assessed by HR-pQCT to detect erosive disease in the second and third MCP joints by CR using empirical estimations for optimal outcome prediction[19]. Sensitivity, specificity, and area under the receiver operating characteristic curve(AUC) are reported.

RESULTS

A flow-chart of patient inclusion is shown in **Figure 1**. The patient demographics and clinical characteristics are shown in **Table 1**. Patients were divided into two groups with regard to erosive damage in the second and third MCP joints by CR. Two-hundred forty-two out of the 353(68.6%) patients did not present erosions in their second and third MCP joints by CR. The remaining 111(31.4%) patients had erosive cortical breaks in their second and third MCP joints(**Figure 2)**. Patients with erosive disease in the second and third MCP joints by CR had larger erosions than patients without erosive disease in the second and third MCP joints by CR; this was seen for all parameters, including maximal width, depth, length and volume.

Patients with erosive disease in the second and third MCP joint by CR were older, had longer disease duration, higher SHS and HAQ scores, and a larger proportion of the patients were RF positive. There was not a significant difference in the proportion of ACPA positive patients in the two groups. Likewise, no significant difference regarding demographics and clinical characteristics was observed(**Table 1**).

OPTIMAL CUTOFF OF HR-PQCT FOR PREDICTING PATIENTS HAVING *EROSIVE CORTICAL BREAKS* IN THE MCP JOINTS DETECTABLE BY CR

The empirical estimation for the optimal cutoff value for the number of erosions in the second and third MCP joints by HR-pQCT was 8.5(95% CI: 5.9 – 11.1) erosions for detecting erosive disease in the second and third MCP joints by CR. The sensitivity and specificity at the cutpoint were 74% and 88%, respectively, with an AUC of 0.81(**Table 2)**(**Supplementary figure 1)**. Empirical estimation for the optimal cutoff value for the total erosive volume in the second and third MCP joints by HR-pQCT was 56.4(95% CI: 3.5 – 109.3) mm^3 for predicting erosive disease in the

second and third MCP joints by HR-pQCT. The sensitivity and specificity at cutpoint were 78% and 83%, respectively, with an AUC of 0.81(**Table 2)**(**Supplementary figure 2)**.

ANATOMICAL DISTRIBUTION OF EROSIONS

A total of 2460 erosions were evaluated; forty percent of erosions were located in the second metacarpal head. The third metacarpal heads and the second proximal phalanx contained 23% and 24% of the erosions, respectively. The last 12% were in the third proximal phalanx. The radial quadrant showed a strong predilection for erosions; this was seen for both metacarpal heads. The most affected site for erosions in the proximal phalanges was the dorsal quadrant, closely followed by the radial quadrant(**Figure 3)**. The erosions were largest in the second metacarpal head, followed by the third metacarpal head, the second proximal phalanx and lastly, the third proximal phalanx. As for the volume of erosions, the volume was largest in the radial quadrant for the metacarpal heads. In contrast, the volume was largest in the dorsal quadrant for the proximal phalanges(**Figure 3)**.

In the second proximal phalanx, joint space narrowing by CR was correlated with the number of erosions($\rho = 0.501$, $p = 0.005$) and total volume of erosions($\rho = 0.467$, $p = 0.009$) by HR-pQCT for the dorsal quadrant only, as illustrated in Figure 4. In the second metacarpal head, joint space narrowing by CR was correlated with the number of erosions($\rho = 0.367$, $p = 0.024$) by HR-pQCT for the dorsal quadrant only.

VOLUME MEASURES

The volume of erosions measured manually or calculated as a half ellipsoid analysed by Bland & Altman plots are shown in **Supplementary figure 3.** The manually measured volume was 5.5 mm^3

higher than the half ellipsoid volume. Still, the interval of ±2 SD was wide(- 97.4 to 86.3 mm^3). When erosions below 20 mm^3 were analysed, the manually measured volume was 0.8 mm^3 higher than the half ellipsoid volume. The interval of ±2 SD was(- 8.3 to 6.8 mm^3). However, it was still evident that the limits of agreement fell with increasing volume.

RELIABILITY

The intrareader reliability(ICC(95%CI)) was 0.998(0.996 – 0.999) for the SHS score, 0.997 241(0.995 – 0.999) for erosions score and 0.990(0.979 – 0.995) for JSN. The interreader reliability was 0.971(0.945 – 0.985) for the SHS score, 0.966(0.937 – 0.982) for erosions score and 0.939(0.887 – 0.967) for JSN. The intrareader reliability for the number of erosions was 0.963(0.914 – 0.984), width 0.818(0.622 – 0.918), depth 0.876(0.728 – 0.945), length 0.814(0.594 – 0.918), volume 0.918(0.817 – 0.964), ellipsoid volume 0.942(0.863 – 0.975). The interreader reliability for the number of erosions was 0.826(0.477 – 0.938), width 0.750(0.486 – 0.859), depth 0.725(0.108 – 0.913), length 0.717(0.593 – 0.799), volume 0.730(0.615 – 0.808), ellipsoid volume 0.595(0.482 – 0.686).

DISCUSSION

This cross-sectional study is the first to evaluate the characteristics of erosions not detected by CR of the second and third MCP joints but is detected by HR-pQCT imaging. Direct comparison of erosion detection by HR-pQCT imaging and CR is scarce in the scientific literature[20–22]. In a previous study, we investigated the diagnostic value of HR-pQCT imaging of the second and third MCP joints from one hand compared to CR of hands, wrist and feet. Although HR-pQCT imaging has a smaller field of view, we found HR-pQCT had equal diagnostic accuracy[6]. In the present study, HR-pQCT imaging detected that if patients presented with fewer than approximately eight erosions in the second and third MCP joints, erosions were poorly detected by CR. Furthermore, we found that CR did not reliably detect patients with erosive damage beneath approximately 50 mm^3.

ANATOMICAL DISTRIBUTION OF EROSIONS

The majority of erosions have previously been shown to be located in the metacarpal heads[22–25]. It is widely accepted that erosions have a predilection for the radial and ulnar quadrants[22,23,25]. The current study found that the erosions were most common in the radial quadrant. Still, the quadrant with the second-most erosion was the dorsal quadrant, especially in the proximal phalanges. The reason for this discrepancy could be related to our cohort having longer disease duration and especially older age. Loss of joint space is related to disease duration and to a larger extent age[26]. The loss of joint space results in the proximal phalanx migrating palmar and proximal towards the metacarpal head. This process erodes more of the bone, primarily at the dorsal quadrant phalangeal base and palmar quadrant of the second metacarpal head. As in the present study, one other study found that erosions were more common in the dorsal than the ulnar quadrant. These patients were not as old as in our cohort but had equivalent disease duration[24].

VOLUME MEASURES

Several studies have estimated the volume of erosions from the width, depth and length using a half ellipsoid formula[13,27–32]. In general, we found that the half ellipsoid formula, on average, underestimated the volume; this underestimation increased as the volume of erosions grew. The calculated volume based upon a half ellipsoid formula has not previously been compared with manually measured volume. Yet, the half ellipsoid formula has been compared with two semi-automated algorithms[27,30]. The two semi-automated algorithms were based on the same principles. Both found that the half-ellipsoid formula tended to underestimate the volume of erosions[27,30]. As seen in the current study, Figueiredo et al. found that the half ellipsoid formula performed progressively worse with the increasing size of erosions[30]. Because of these results, we recommend that the volume of the cortical breaks should not be calculated by the half-ellipsoid formula.

RELIABILITY

In general, we observed moderate to high reproducibility with regard to inter and intrareader reliability for number and size measures of cortical breaks. The interreader reliability of manually measured volume was higher than the calculated half-ellipsoid volume. Together with a previous study showing the reliability after repositioning is higher for the manually measured volume compared to measures of wide, depth and length[24], our results further illustrate the limitations of this method of estimating erosive volume.

STRENGTH & LIMITATIONS

The strengths are as follows. First, the study includes the RACTX cohort, which presently is the largest cohort included to investigate erosions by HR-pQCT in inflammatory rheumatic disease [5].

Secondly, none of the patients HR-pQCT scans were excluded due to severe deformity as is seen in many HR-pQCT studies[10,17,21,29,33–36]. Thirdly, inter-and intrareader reliability was investigated for HR-pQCT imaging.

Conclusion

Erosions by HR-pQCT were larger in patients with erosive damage in the second and third MCP joints by CR. We found that CR had poor sensitivity for erosive disease when the volume was less than approximately 50 mm^3. Furthermore, we observed that the patients should have approximately eight erosions in the second and third MCP joints for optimal detection on CR. Our results demonstrate the potential risk of CR misclassifying RA patients as having non-erosive disease, despite having considerable erosive cortical breaks to their joints.

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CONFLICTS OF INTEREST

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AUTHOR CONTRIBUTIONS

All authors were involved in drafting the article or revising it critically for important intellectual content. All authors approved the final version to be published.

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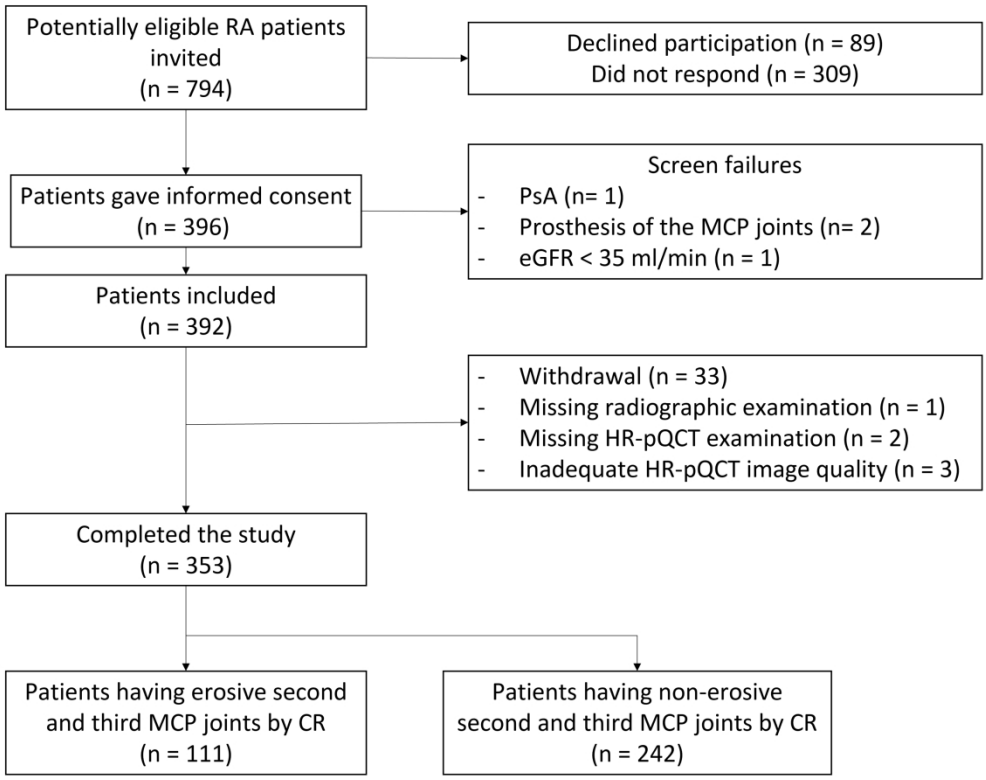

Figure 1
Flow-chart showing the identification, inclusion and exclusion of research subjects. Conventional radiography (CR), Estimated glomerular filtration rate (eGFR), High resolution peripheral quantitative computed tomography (HR-pQCT), Metacarpophalangeal joint (MCP), Psoriatic arthritis (PsA).

275x218mm (300 x 300 DPI)

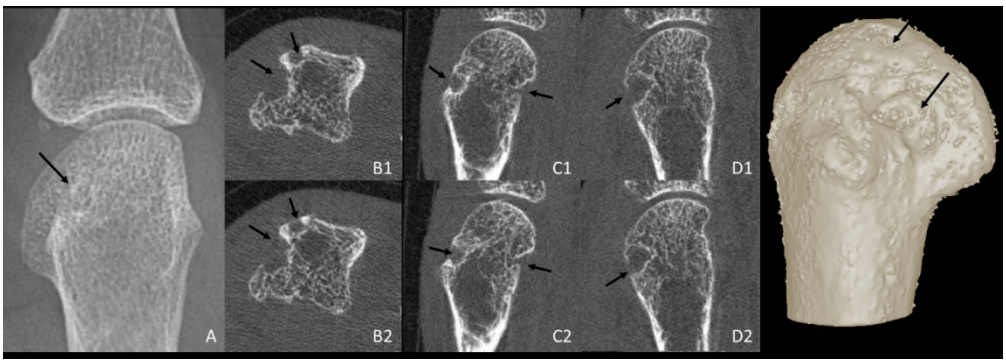

Figure 2
Images of erosions in the left second metacarpophalangeal (MCP) joint in a 75-year-old female patient. Conventional Radiography of the second MCP joint, erosions not visible (A), consecutive slices from HR-pQCT imaging in the axial plane (B1, B2), Coronal plane (C1, C2), sagittal plane (D1, D2) and the 3D segmentation (E). 3D segmentation was performed using thresholding (3D Slicer, http://www.slicer.org).

168x59mm (220 x 220 DPI)

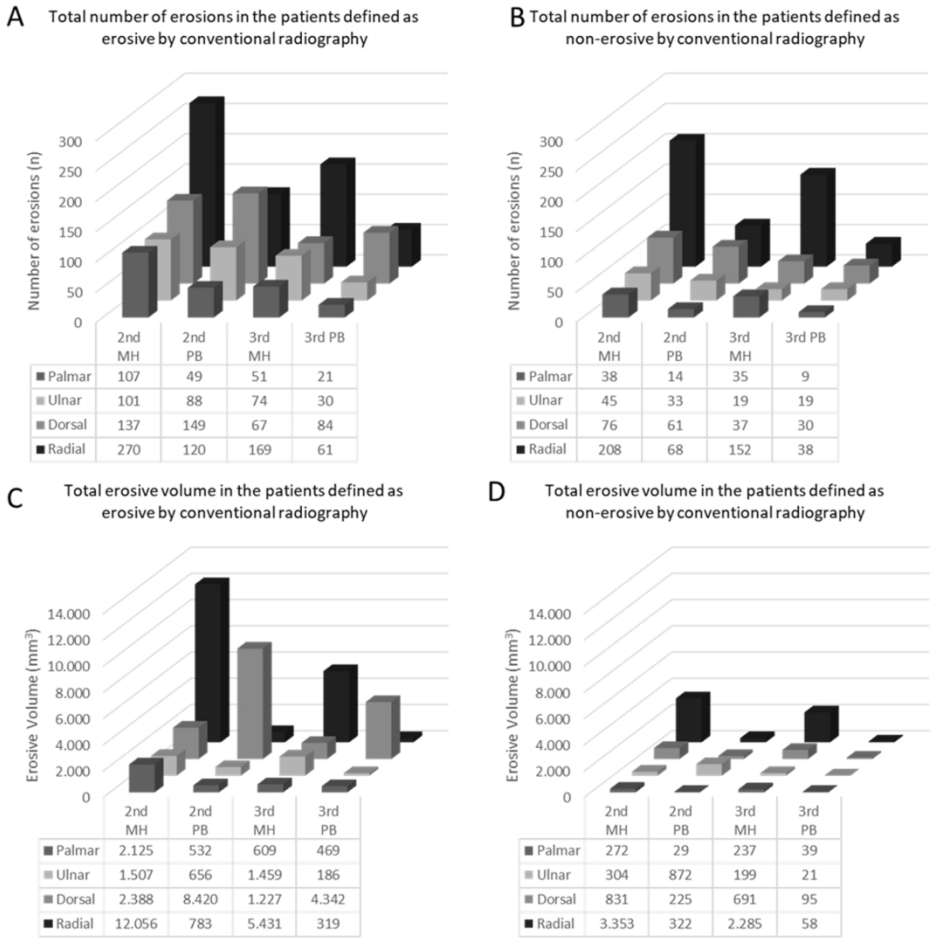

Figure 3
The total number (A-B) and erosive volume (C-D) of erosions according to the bone in the second and third metacarpal head (MH) and phalangeal base (PB) assessed by HR-pQCT in the patients defined as either erosive (A, C) or non-erosive (B, D) in the second and third metacarpophalangeal joints by conventional radiography.

174x170mm (330 x 330 DPI)

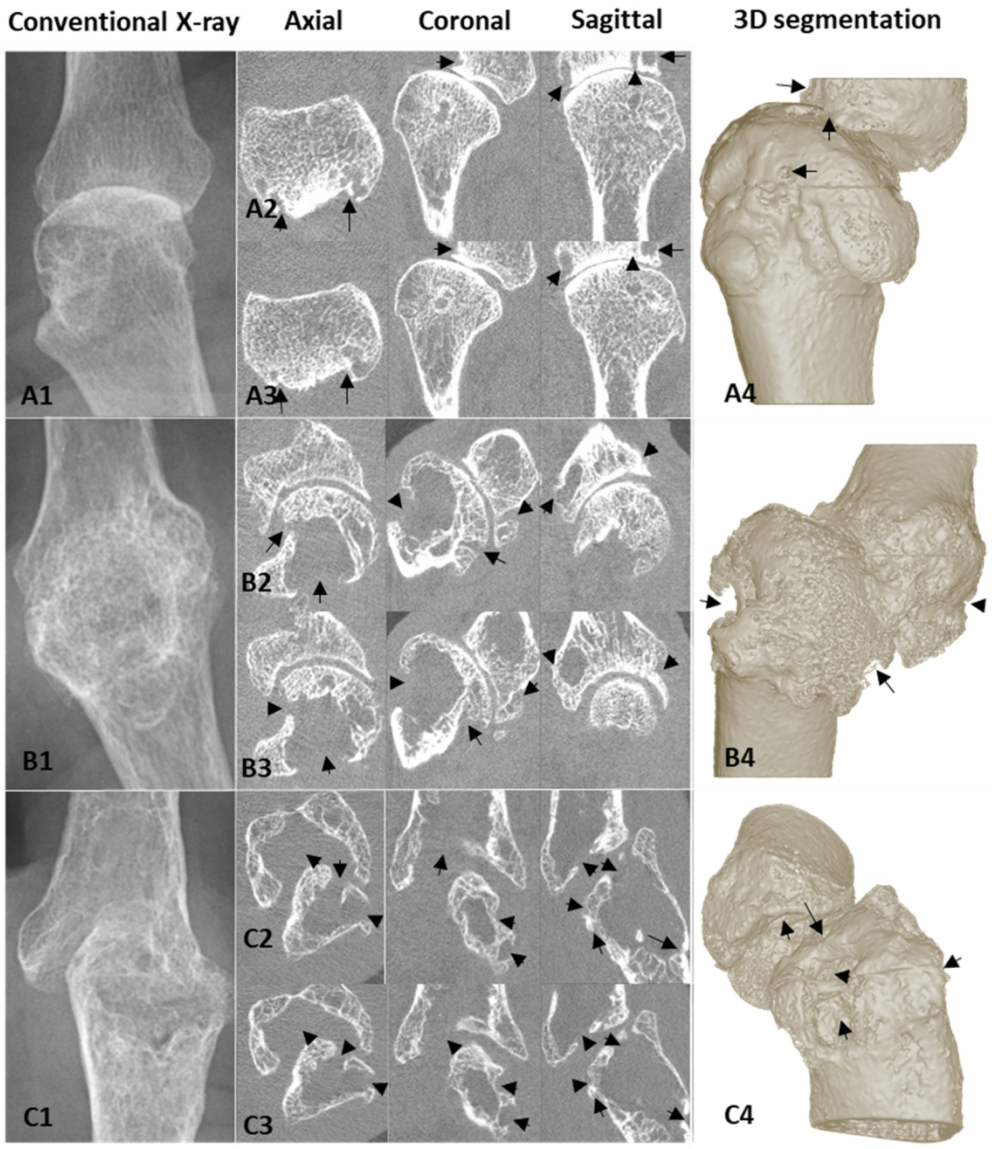

Figure 4
Patients with severe erosive damage. Arrows denote cortical breaks. Note the severe deformity, especially to the dorsal quadrant of the proximal phalanx. Conventional radiography (CR) of the second MCP joint from an 80-year-old male patient (A1), (A2, A3) are consecutive slices from HR-pQCT imaging and (A4) is the 3D segmentation. CR of the second MCP joint from a 73-year-old female patient (B1), (B2, B3) are consecutive slices from HR-pQCT imaging and (B4) is the 3D segmentation. CR of the second MCP joint from a 72-year-old male patient (C1), (C2, C3) are consecutive slices from HR-pQCT imaging and (C4) is the 3D segmentation. 3D segmentation performed using thresholding (3D Slicer, http://www.slicer.org).

139x163mm (330 x 330 DPI)

Table 1 | Clinical Characteristics of the Participants

	Patients having non-erosive 2nd and 3rd MCP joints by CR (n = 242)	Patients having erosive 2nd and 3rd MCP joints by CR (n = 111)	*p-value*
Age(years), median(IQR)	62.7(51.6 to 70.6)	66.6(61.2 to 71.3)	**< 0.001**
Female, n(%)	176(27.6)	77(30.6)	0.554
Weight(kg), median(IQR)	73(63 to 85)	70(60 to 81)	0.165
Height(cm), median(IQR)	169(164.2 to 175)	168(162 to 174)	0.148
Body Mass Index(kg/m²), median(IQR)	24.8(22.2 to 28.1)	25.0(22.2 to 27.4)	0.630
Disease Duration(years), median(IQR)	12.0(7.0 to 19.0)	21.0(13.0 to 33.0)	**< 0.001**
Sharp/van der Heijde score, median(IQR)	11(2 to 26)	67(23 to 160)	**< 0.001**
Erosions, median(IQR)	4(0 to 12)	30(11 to 77)	**< 0.001**
Joint Space Narrowing, median(IQR)	7(0 to 16)	34(13 to 75)	**< 0.001**
RF positive, n(%)	147(60.5)	80(72.1)	**0.035**
ACPA positive, n(%)	169(69.5)	87(78.4)	0.085
ACPA and RF positive, n(%)	130(53.5)	73(65.8)	**0.030**
Patients with Tender joints at inclusion, n(%)	80(32.9)	32(28.8)	0.442
TJC count, median(IQR)	0(0 to 1)	0(0 to 1)	0.444
Patients with Swollen joints at inclusion, n(%)	41(16.9)	27(24.3)	0.099
SJC count, median(IQR)	0(0 to 0)	0(0 to 0)	0.154
Visual Analog Scale			
Pain, median(IQR)	16(5 to 35)	16(7 to 45)	0.452
Fatigue, median(IQR)	27(10 to 56)	24(9 to 52)	0.301
Global, median(IQR)	18(6 to 41)	18(7 to 35)	0.961
Provider, median(IQR)	7(0 to 7)	1(0 to 6)	0.423
Plasma CRP(mg/L), median(IQR)	2(1 to 4.5)	2(2 to 5.6)	0.120
HAQ, median(IQR)	0.25(0 to 0.875)	0.5(0 to 1.125)	**0.017**
DAS28CRP, median(IQR)	1.9(1.5 to 2.6)	2.0(1.6 to 2.5)	0.741
CDAI, median(IQR)	2.7(0.9 to 6.6)	2.8(0.8 to 5.5)	0.913
SDAI, median(IQR)	5.5(2.9 to 10.8)	6.4(3.5 to 12.2)	0.375
Charlson Comorbidity Index, median(IQR)	1(1 to 1)	1(1 to 2)	0.195
Smoking(Pack year), median(IQR)	7.5(0 to 20)	5(0 to 25)	0.955
Current, n(%)	50(20.6)	25(22.5)	0.678
Former, n(%)	109(44.9)	42(37.8)	0.216
Never, n(%)	84(34.6)	44(39.6)	0.357
Weekly Alcohol consumption			
< 7, n(%)	192(79.0)	81(73.0)	0.210
7-14, n(%)	40(16.5)	25(22.5)	0.172
14-21, n(%)	10(4.1)	3(2.7)	0.512
> 21, n(%)	1(0.4)	2(1.8)	0.186
Oral prednisolone, n(%)	13(5.3)	11(9.9)	0.113
csDMARD, n(%)	183(75.3)	82(73.9)	0.773
bDMARD, n(%)	110(45.0)	50(45.3)	0.969
csDMARD and bDMARD, n(%)	69(28.4)	36(32.4)	0.440
Janus kinase inhibitor, n(%)	6(2.5)	1(0.9)	0.326

Anti-Citrullinated Protein Antibody(ACPA), biological Disease-Modifying Antirheumatic Drug(bDMARD), C-Reactive Protein(CRP), conventional synthetic Disease-Modifying Anti-rheumatic Drug(csDMARD), Disease Activity Score in 28 Joints-C-Reactive Protein(DAS28CRP), Health Assessment Questionnaire(HAQ), Interquartile Range(IQR), Rheumatoid Factor(RF), Simplified Disease Activity Index(SDAI).

Table 2 | The optimal cutoff for the number of erosions, and total erosive volume by HR-pQCT for predicting erosive disease by conventional radiograph (CR) in the second and third MCP joints.

	Joints	Empirical optimal cutpoint (95% Confidence interval)	Sensitivity, Specificity and AUC at cutpoint
Number	2nd & 3rd MCP joint	8.5 (5.9 – 11.1)	0.74, 0.88, 0.81
	2nd MCP joint	4.5 (3.0 – 6.0)	0.89, 0.81, 0.85
	3rd MCP joint	3.5 (2.7 – 4.3)	0.77, 0.88, 0.83
Total erosive volume	2nd & 3rd MCP joint	56.4 (3.5 – 109.3)	0.78, 0.83, 0.81
	2nd MCP joint	43.5 (30.2 – 56.7)	0.84, 0.85, 0.85
	3rd MCP joint	24.0 (1.2 – 46.8)	0.77, 0.81, 0.79

Area under the Curve (AUC), High Resolution peripheral Quantitative Computed Tomography (HR-pQCT), Metacarpophalangeal (MCP)