Relative, Reliability-Adjusted Diagnostic Test Accuracy of Erosion Detection Between Magnetic Resonance Imaging and Radiography in Rheumatoid Arthritis

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Background

- In rheumatoid arthritis (RA), erosion detection on X-ray compared to magnetic resonance imaging (MRI) is characterized by low sensitivity and high specificity (1-3)
- This supports the hypothesis that MRI has a lower limit of detection for erosion than X-ray
- To date, however, no studies have directly assessed measurement reliability

Objectives

- To determine the relative diagnostic test accuracy of MRI and X-ray for erosion detection while accounting for inter-rater reliability

Methods

- A paired, cross-sectional study of 65 RA patients
- MRI of the bilateral metacarpophalangeal joints (MCP) 2-5 and X-ray of both hands, wrists and feet were taken.
- OMERACT RA MRI score (RAMRIS) and van der Heijde-modified Sharp (vdHSS) scores were used to evaluate the MRI and X-ray images, respectively (**Fig. 1**) (4,5).

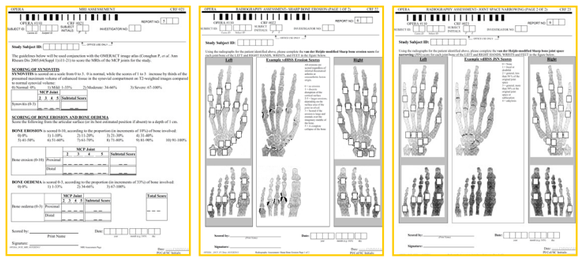

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Fig. 1. Evaluation forms for RAMRIS (a) and vdHSS erosions (b) and JSN (c).

- Data paired at smallest common level of analysis: the joint
- A total of 488 paired joints were compared.
- Odds ratio, sensitivity, specificity, and accuracy calculated and the smallest detectable difference (SDD)-adjusted and unadjusted evaluations were compared

Results

- Study participants included a range characteristics (**Table 1**)

Table 1. Select study participant characteristics.

Baseline Characteristic	Value
Demographics	
Age, years, median (quartiles)	59 (49-66)
Male, n (%)	11 (17)
Symptom duration, years, median (quartiles)	4.3 (2.6-7.0)
Clinical Assessments	
Tender joint count, 28-joint, median (quartiles)	5.0 (1-13)
Swollen joint count, 28-joint, median (quartiles)	10.0 (5-13)
Laboratory Tests	
C-reaction protein, mg/L, median (quartiles)	6.1 (3.0-21.9)
Erythrocyte sedimentation rate, mm/h, median (quartiles)	22.0 (10.0-32.0)
Rheumatoid factor positivity, n (%)	46 (70.8)
Composites	
DAS28, median (quartiles)	4.5 (3.3-5.7)
HAQ, median (quartiles)	1.5 (0.5-3.2)
vdHSS, hands, wrists and feet, median (quartiles)	14.0 (4-33)
RAMRIS, dominant MCP 2-5, medina (quartiles)	9.0 (5-14)

- At Joint level of analysis, SDD adjustment increased odds ratio, specificity, and accuracy of association between X-ray & MRI erosion detection (**Table 2**)
  - Number of erosions detected & sensitivity decreased

Table 2. MCP 2-5 bone erosions detected on radiography and MRI with MRI as the reference standard (n=65; n_{hand}s=122; n_{Joints}=488).

Property	Evaluation	
	Raw	SDD-adjusted
Odds ratio, mean (95% CI)	1.8 (1.2-2.9)	3.2 (1.5-6.1)
True positive, n	103	17
False positive, n	31	27
False negative, n	228	74
True negative, n	126	370
Sensitivity, mean (SD)	0.31 (0.03)	0.19 (0.04)
Specificity, mean (SD)	0.80 (0.03)	0.93 (0.01)
Accuracy, mean	0.47	0.79

SDD_{MRI}=2; SDD_{xray}=2. SDD = smallest detectable difference.

- Number of erosions detected per joint decreased (**Fig. 2**):
  - From 67.8% to 18.6% on MRI
  - From 27.5% to 9.8% on X-ray
- Per MCP joint, 2.6- to 8.0-times as many erosions detected on MRI compared to X-ray
- Compared by MCP 2-5 joint set, SDD adjustment resulted in MRI detection of 2.1-times the erosive disease detected on X-ray

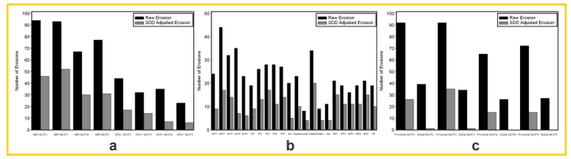

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Fig. 2. Raw (black) and SDD-adjusted frequency (grey) of erosion detection (*per unit of measurement*). a) MRI (*bone*) , b) x-ray (*joint*), and c) anatomy common to both imaging modalities (*joint*).

- At patient level of analysis, difference in erosion detection between X-ray & MRI depends on anatomy imaged (**Fig. 3**).
  - Bilateral MRI of the MCP 2-5 joints resulted in the detection of erosive disease in 1.1-fold the number detected on X-ray of hands, wrists and feet
    - McNemar test, p = 0.83
    - Cohen's k=0.17 (0.13), p=0.16
    - Similar proportions comprised of different patients

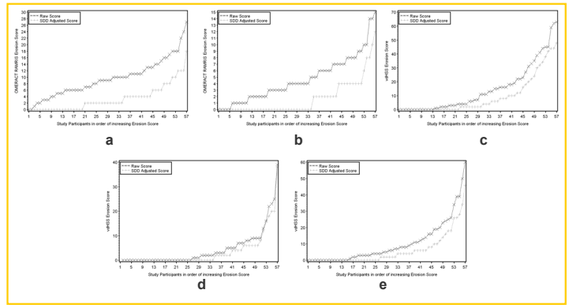

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Fig. 3. Cumulative probability plot of raw (x) and unit-of-measurement-SDD-adjusted (+) RAMRIS & vdHSS erosion subscores at patient level of analysis: a) MRI using RAMRIS of bilateral MCP 2-5 joint sets; b) RAMRIS of dominant hand MCP 2-5 joints; c) vdHSS of the hands, wrists and feet; d) vdHSS of the feet; e) vdHSS of the hands and wrists.

- Correlation between SDD-adjusted vdHSS erosion score and symptom duration was 0.37 (p<0.0001).
- Correlation between MRI and symptom duration was non-significant (0.10, p=0.26).

Conclusions

- Unit-of measurement-SDD-adjustment results in less disparity in erosion detection between imaging modalities
- Per joint imaged MRI detects more erosions than X-ray (1-3)
- At the patient level of analysis, the relative performance of the two imaging modalities is highly dependent on the anatomy imaged (6)
- Comparing erosion detection between bilateral MRI of MCP 2-5 and X-ray of the hands, wrists and feet,
  - Similar proportions with erosive RA detected
  - The greater number of joints imaged on X-ray offsets the lower limit of detection of MRI for erosion per joint
  - Non-significant, low level of agreement indicates proportions detected by each modality are largely unique
- The interaction with symptom duration suggests that MRI may detect a greater proportion of patients with erosions at earlier stages of disease progression.
  - MRI may have greater utility for erosion detection in early disease
- Unique clinical implications for each modality

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