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3D Location of Erosions in an Early Rheumatoid Arthritis Population: An MRI Study Using Statistical Shape Models with Implications for Pathogenesis

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Background/Purpose: Concepts of erosion pathogenesis in rheumatoid arthritis (RA) have been based on radiographs, although MR images are much better able to visualise erosions. Statistical shape models (SSM) allows bones and erosions to be aligned, correcting for size and patient shape, allowing the 3D study of systematic effects. This study employed SSMs to visualise the spatial distribution of erosions, and their probability of arising at a particular location, in a population of early RA patients.

Methods: 90 baseline MR images were selected at random from an exploratory Phase 2 multicentre study (NCT01164579). Inclusion criteria were as follows: MTX-naïve adult patients with early RA (duration ≤ 2 years); diagnosis using ACR criteria, unequivocal evidence of radiographic erosion, and clinical evidence of synovitis. 7 images were not analysed due to image quality. Bones and erosions were manually segmented and independently reviewed. 3D bone and erosion surfaces were generated, and rigidly warped to the mean bone shape. A population image was created; containing the number of times that each voxel was found within an erosion. Voxels which were present in >2 erosions were displayed along with the mean bones. (Figure 1)

Results: Erosions were present in low numbers of patients. In 18 patients there were no erosions visible in MR despite reported radiographic erosions. Over half had only 0 to 2 bones with an erosion. Erosions exhibited a clear spatial pattern. In the metacarpals, the erosions were most prevalent in MCP2 and 3 (Table 1). In the wrist, there were typically 20 erosions per bone for half of the bones; the trapezium, trapezoid and proximal metacarpals had ~10. Erosions occurred at consistent sites, with only one or 2 sites within each bone where the erosion was found in >2 patients.

Conclusions: This is the first study to provide an accurate 3D visualisation of erosion sites in early RA. Erosions occurred at only a small number of entheseal sites. Erosions in the metacarpals occurred in the area containing the collateral ligament and capsular attachments. In the wrist, the erosions were located primarily on the palmar side of the bone, and had a more complex arrangement. Although multiple ligament, capsular and tendon attachments exist in close proximity on each bone, we observed that erosion sites were usually those in which there was a deep attachment site in non-eroded patients. This suggests that the attachments which will generate an erosion are those which experience the highest mechanical load. Further careful study will be required to pursue the detail of these anatomical locations, and will significantly help our understanding of the pathogenesis of RA erosions.

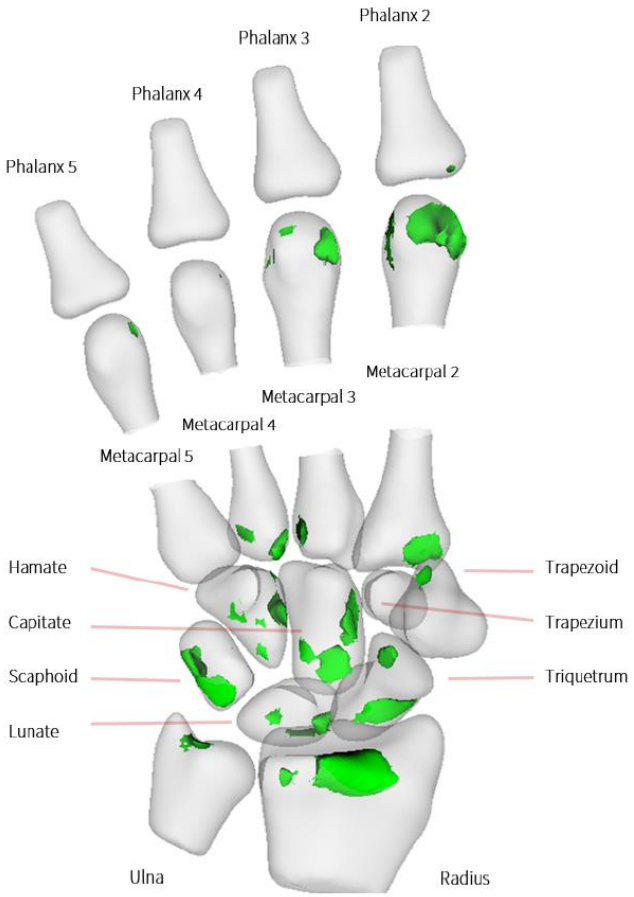

Figure 1 – Erosions occurring in more than 2 patients. Mean bone surfaces are shown as partly transparent, viewed from the palmar direction. Maximum number of erosions for each bone are provided in Table 1

Bone	Number of erosions
MCP	
Phalanx 2	6
Phalanx 3	2
Phalanx 4	1
Phalanx 5	1
Metacarpal 2	31
Metacarpal 3	26
Metacarpal 4	8
Metacarpal 5	17
WRIST	
Metacarpal 2	13
Metacarpal 3	11
Metacarpal 4	10
Metacarpal 5	2
Hamate	18
Capitate	29
Trapezium	11
Trapezoid	12
Scaphoid	21
Lunate	21
Triquetrum	23
Radius	24

Table 2 – Number of erosions per bone