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Quantitative MRI Measurement of Tenosynovitis Demonstrates Differing Responses of Synovitis and Tenosynovitis after RA Treatment

Michael A. Bowes[1], Gwenael Guillard[1], Graham R. Vincent[1], Jane E. Freeston[2], Edward M. Vital[2], Paul Emery[2], Philip G. Conaghan[2]

[1] imorphics Ltd, Manchester, UK, [2] Leeds Institute of Rheumatic and Musculoskeletal Medicine, University of Leeds, Leeds, UK

Background/Purpose: Inflammation of the tendon sheaths (tenosynovitis) is a recognised component of rheumatoid arthritis (RA). A comprehensive assessment of inflammation will require the inclusion of tenosynovitis as well as synovitis and osteitis, and consequently it is proposed to include a semi-quantitative assessment of wrist tenosynovitis in the OMERACT RAMRIS scoring system. Active appearance models (AAM) have been successfully used to develop an automatic quantitative version of the current RAMRIS methodology. This study was a pilot investigation in established RA to assess whether AAMs can be used to produce an automatic tenosynovitis measure and compare the response to therapy of quantitative wrist tenosynovitis and synovitis measures.

Methods: MR images of the hand were acquired at 0, 3 and 6 months from 34 established, seropositive RA patients who received a cycle of rituximab therapy in an open label study. Pre- and post-contrast VIBE images with fat saturation were acquired, and searched with AAMs to identify bones and capsular structures and generate 3D regions of interest (ROIs). Volume which enhanced with contrast was calculated using a shuffle transform. AAMs of the flexor tendons were generated from an independent training set of hand MR images. Briefly, the process includes manual segmentation of the tendons by an expert, generating 3D surfaces using a marching cubes algorithm and the generation of AAMs for each tendon. Images were automatically searched using the AAM, and visually inspected to ensure that the search process had correctly identified the tendons. A 3D region of interest (ROI) around each tendon was created by inflating the tendon shape to form a halo which included the tendon sheath. Within the ROI the tenosynovitis volume was calculated using the shuffle transform method. For this pilot study only the wrist flexor tendons within the common synovial sheath were analysed. The amount of change for the 2 methods was judged using a paired t-test.

Results: Tenosynovitis in the flexor tendons, and synovitis volume decreased at 3 and 6 months, in an approximately linear fashion. Change was significant at 6 months for both measures (Figure 2). Although the change in the population mean was linear for both measures, the slope of change in tenosynovitis volume for individual patients did not correlate with change in synovitis volume for the same patients ($r^2 = 0.29$).

Conclusions: It is feasible to quantify tenosynovitis using AAMs. Tenosynovitis in the flexor tendons decreased over 6 months, and only correlated weakly with change in synovitis volume within the same patient. Tenosynovitis appears to be as responsive as synovial volume, but did not correlate with synovial change in individual patients in this small study. Tenosynovitis may therefore add new information to that already provided by measures of

synovitis, though this will need confirmation with a fully developed tool in a larger RA population.

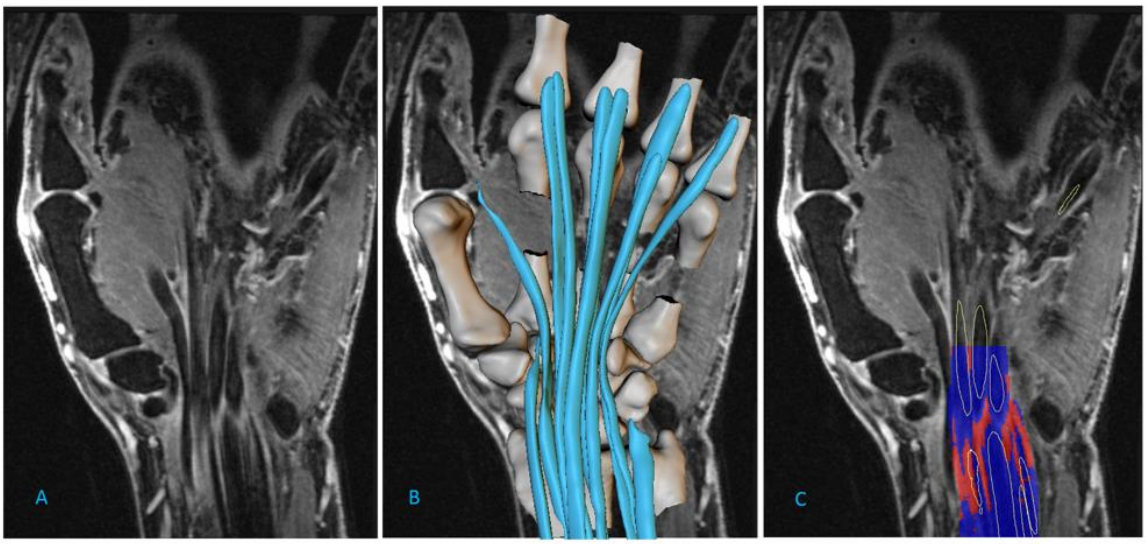

Figure 1 – Using appearance models to automatically identify bone, and generate 3D regions of interest. Figure A shows a single slice in a typical post-contrast VIBE image from this study. The 3D image is searched using an active appearance model (AAM), which generates surfaces for all the bones and flexor tendons in the hand (B). C shows the areas which enhance in the 3D region of interest around the flexor tendons in the ulnar bursa group of flexor tendons (enhanced voxels coloured red, region of interest coloured blue)

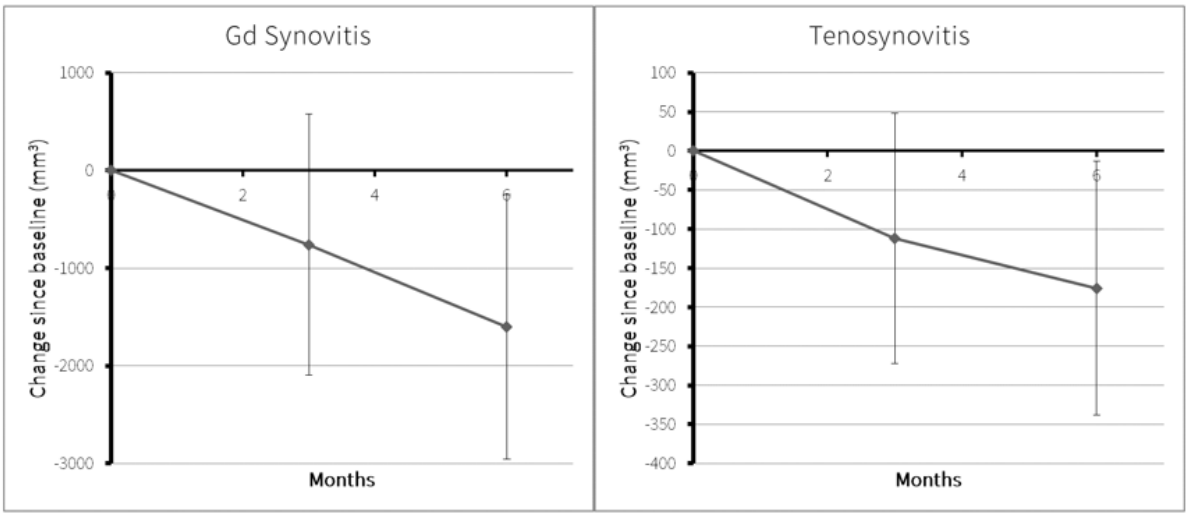

Figure 2 – Change from baseline at 3 and 6 months. 34 patients had images at 0, 3 and 6 month time points. Graphs show change in synovitis volume (microliters or mm^3) and tenosynovitis volume in the ulnar bursa, showing 95% confidence limits for change from baseline using a paired t-test.