Diffusion Weighted MRI for assessing treatment response in myeloma bone disease

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Introduction There is growing interest in diffusion weighted (DW) MRI as a biomarker of treatment response in metastatic and myeloma bone disease. The predominance of fat requires consideration when interpreting of DW MRI of normal adult bone marrow because return of normal fatty marrow following treatment leads to a fall in ADC. In contrast response with necrosis will result in an ADC rise. The study aims therefore were 1. To compare ADC values in normal adult marrow with ADC values from marrow with myeloma involvement 2. To investigate the feasibility of segmentation techniques based on ADC differences of normal and pathological marrow in order to determine feasibility of using a threshold value of ADC for identifying marrow involvement with myeloma.

Methods DW MRI of lumbar spine and pelvis of 23 healthy volunteers was performed : Siemens Avanto 1.5T, axial plane, slice thickness 5mm, TR 3600ms, TE 70ms, 7 averages, 3 orthogonal directions and b values of 0, 50, 250, 750, 1300, 1400 smm^{-2} with SPAIR. Corresponding T1W imaging was also performed to guide ROI placement. Monoexponential ADC maps were generated using system software. 2.3cm^2 ROIs were drawn on ADC maps avoiding areas of artefact in L5, right and left iliac bones. 8 patients with myeloma also underwent DWI lumbar spine and pelvis and ROIs (up to 6 per patient) were drawn around lesions or whole bone if disease was diffuse. ROC analysis was performed (SPSS vs 15). Thresholds derived from the ROC analysis were used to segment whole vertebral body data from a further patient with diffuse myeloma disease before and after treatment into normal and pathological marrow (Diffusion View).

Results 66 regions of interest were drawn on ADC maps of healthy volunteers (mean age 48.0 years) and 42 on ADC maps of patients with myeloma (mean age 67.1 years). The mean ADC of normal marrow was 543.7 mm^{2}s^{-1}x 10^{-6} and the mean ADC of myeloma marrow disease was 1234.7 mm^{2}s^{-1}x 10^{-6}.

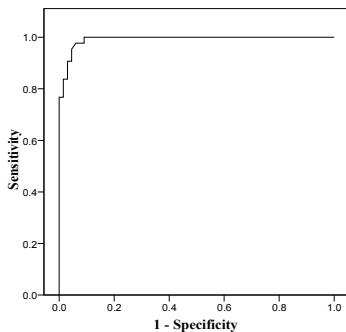
Fig1. ROC curve for normal vs myeloma involved marrow. Using an ADC threshold of 724 mm^{2}s^{-1} x 10^{-6} the sensitivity and specificity for detecting myeloma marrow involvement are 90 and 70% respectively.

Discussion and Conclusion

Contrast between normal adult marrow and myeloma marrow disease on DW MRI allows disease to be segmented from normal marrow with a high sensitivity and specificity. Interrogation of the relationship between fat/water fraction derived from 2 point Dixon MRI and ADC and measurement

Figure 2: Example case. Segmented ADC maps of the L5 vertebral body (normal marrow colour coded yellow and myeloma disease coded red) overlaid on b1400 DW images of a man with myeloma at baseline (A), after 4 weeks chemotherapy (B) and after 20 weeks chemotherapy (C). Histogram ADC data from the whole L5 vertebral body (D) confirms an increase in the pixel count of normal fatty marrow values from 3 to 275 to 686 at 0, 4 and 20 weeks respectively. We hypothesised that the return of fatty marrow indicated treatment response and the absence of any red pixels at 20 weeks suggests complete response. Fat only images of the lumbar spine (E) using a 2 point Dixon technique provide further validation that ADC changes reflect an increase in fatty marrow. Marrow trephine at the same timepoints showed 40% plasma cells, <1% plasma cells and complete response respectively, confirming our findings.

of changes in fat using segmented ADC maps is warranted to establish utility of DW MR as a response biomarker in bone marrow.

References 1.Messiou C, Collins DJ, Morgan VA and de Souza NM et al, Abstract 3943. ISMRM 2009.