The bench tool: quantitative MRI-based method for measuring oedema and fat metaplasia in spondyloarthritis

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Background: Magnetic resonance imaging (MRI) is an important part of diagnostic pathways in spondyloarthritis (SpA), and can be used to stratify patients and assess severity. However, measurements of the burden of inflammation currently rely on qualitative assessment, which is subjective and time-consuming thus impractical for clinical practice. There is a need for a more objective, faster method for measuring inflammation and damage with potential for automation, and quantitative MRI is a candidate tool.

Objectives: We aimed to provide proof-of-principle for the BEACH (Bone OEdema and Adiposity quantification with Apparent diffusion coefficient and Chemical shift imaging with histograms) tool, which quantifies bone marrow oedema and fat metaplasia – features of active and chronic inflammation – in the SIJs.

Methods: Fifty-three patients aged 12–24 years with either SpA or mechanical back pain were recruited prospectively, and underwent quantitative MRI consisting of diffusion weighted imaging (DWI) and fat fraction (FF) mapping,[2,3] and conventional MRI scans. Apparent diffusion coefficient (ADC) and FF maps were assessed using the BEACH tool, which automatically propagates ROIs on subchondral bone after the observer defines the SIJ. Pixel values were analysed to derive the histographic parameters for ADC and FF: median, 10th, 25th, 75th and 90th percentiles (denoted ADC_{10}, ADC_{25}, FF_{10}, FF_{25}, etc), and p_{high} and plough (the proportion of high and low value pixels respectively).

Conventional MRI scans were assessed using visual scoring.[4] Patients were deemed to have active inflammation if their inflammation score was ≥2, and to have fat metaplasia if this score was ≥3. Quantitative measurements were compared between inflamed and non-inflamed SIJs.

Results: Use of the BEACH tool is demonstrated in figure 1(a)-(f). Example ADC histograms are shown in (g),(h).

ADC_{75}, ADC_{90}, and $p_{high(ADC)}$ were significantly increased in inflamed SIJs (P=0.041, 0.006 and 0.003 respectively), although median ADC values did not differ significantly between inflamed and uninflamed joints (P=0.31). Diagnostic performance was superior for histographic parameters (AUC=0.59, 0.67 and 0.69) than for the median (AUC=0.54) Median FF, FF_{75}, FF_{90} and $p_{high(FF)}$ were all significantly increased in SIJs with fat metaplasia compared to those without (all $p<0.0001$). Diagnostic performance was superior for histographic parameters FF_{75}, FF_{90} and $p_{high(FF)}$ (AUC=0.89, 0.92 and 0.92) than for the median (AUC=0.87).

Conclusions: ADC and FF measurements can differentiate between inflamed and non-inflamed SIJs, and between joints with and without fat metaplasia. Compared to simple averages such as the median, histographic parameters can increase diagnostic performance for detecting inflammation and fat metaplasia. There is minimal subjectivity associated with ROI placement using the BEACH tool, which can potentially make inflammation scores more reproducible.