Can texture analysis of MR images discriminate the severity of hepatic fibrosis? A patient study with histological correlation

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Introduction

In common with all routinely used imaging methods, MRI is insensitive to the development of hepatic fibrosis and cirrhosis until end-stage cirrhosis has developed when macroscopic morphological changes such as segmental fibrosis, marginal nodularity and varices develop. Diffuse rather than focal changes are more difficult to detect visually and previous work has demonstrated that computer-based texture analysis of T2w MR images [2,3] can distinguish between healthy volunteers and cirrhotic patients. Texture analysis is a method of examining the relationships between adjacent pixels to find a statistical way of describing patterns in an image. Such analysis has proven to be a useful tool in ultrasound examination of the liver [1]. In our previous work, high-resolution T2w images from a cohort of healthy volunteers and patients with end-stage cirrhosis were used as a training dataset to identify the most discriminating texture parameters. This work takes three of these parameters and examines how well the parameters discriminate patients with intermediate grade fibrosis, as demonstrated by histology (i.e. treating this group as an evaluation dataset). Within texture analysis, important decisions must be taken about the normalisation and discretisation processes (figure 1): this paper explores the potential effect of varying the latter.

Methods

12 healthy volunteers (7 male, 5 female, age range 23-56), with no history of liver disease and 14 patients (11 male, 3 female, age 43-75) with biopsy proven cirrhosis undergoing routine surveillance MRI were recruited: informed written consent was obtained. All examinations were performed on a 1.5T whole body MRI (Excite, GEHT, Milwaukee) with an 8-channel body array and a fast-recovery fast spin echo sequence (TEeff 68 ms, matrix 512 x 380, echo train 13, section thickness 8mm, intersection gap 2mm, FOV 34cm, tailored RF pulse, RBW 62.5 kHz, spectral fat suppression). Respiratory triggering was used with a TR of at least 4.8 seconds (TR range 4.8-10.9 seconds) giving an acquisition time of 6-12 minutes. Image textures were quantified using the Mazda texture analysis programme (v 3.2 [3]). After normalisation of the intensities within the ROI to the mean +/- 3 standard deviations, the images intensities of the FRFSE images were 'binned' in two different ways: (A) into 64 distinct grey levels and (B) into 16 distinct grey levels to determine whether this would have a significant effect on the discrimination provided by the statistics. Circular regions of interest (3000 pixels) were selected within the liver, avoiding the major vessels. The biopsy specimens were graded by a single expert liver pathologist in a retrospective review using the Ishak scale for fibrosis (0-6): different fibrosis grading scales give weighting to emphasis different aspects of fibrosis.

Table 1: Texture parameters used in the study

Texture Parameter	Short description of texture parameter
S(1,0)AngScMom	Angular second moment for horizontally adjacent pixels
S(3,0) Entropy	Entropy (natural logarithm of the co-occurrence matrix) for a horizonatal 3-pixel spacing
GrNonZeroes	The percentage of pixels in the ROI where adjacent pixels have different signal intensity

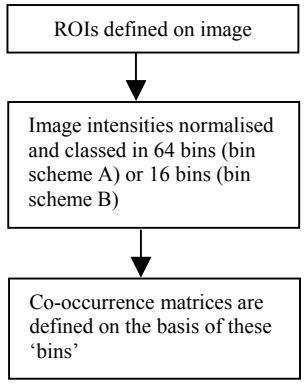

Figure 1: Pre-processing steps necessary in texture analysis.

Results

The plot of the Ishak fibrosis grade plotted against the texture parameters is shown in figure 2(a-f). It can be seen that there is considerable overlap between the groups and that only 3 patients fall into the fibrosis groups 2 and 3. The results for S(3,0)Entropy and S(1,0)AngScMom using scheme A are shown in figure 1(a) and (b). While there is a good discrimination between the healthy volunteers and the patients with fibrosis grades 3-6, (indicated by the horizontal line), no discrimination is possible between the fibrosis grades 3-6. Using bin scheme B, the same texture parameters were evaluated. For S(1,0)AngScMom and S(3,0)Entropy, there was little difference in the parameters recorded (figures 1(d) and (e)). The GrNonZeros texture parameter, although promising in the initial study, shows overlap between the healthy volunteers and those with end-stage cirrhosis using both bin schemes (fig 1(c)&(f)), with less discrimination possible when bin scheme B (16 bins) was used.

Conclusions

This work demonstrates that two of the parameters identified from the training cohort were capable of distinguishing between healthy volunteers and end-stage cirrhotic patients. However, due to the spectrum of morphological changes observed in fibrosis, including the degree of portal and lobular fibrosis, a larger cohort will be required to evaluate the value of these parameters for identifying intermediate degrees of fibrosis. The selection of different binning ranges in this work did not greatly influence the results for two of the parameters, but did for a third.

Acknowledgement: FFA

References

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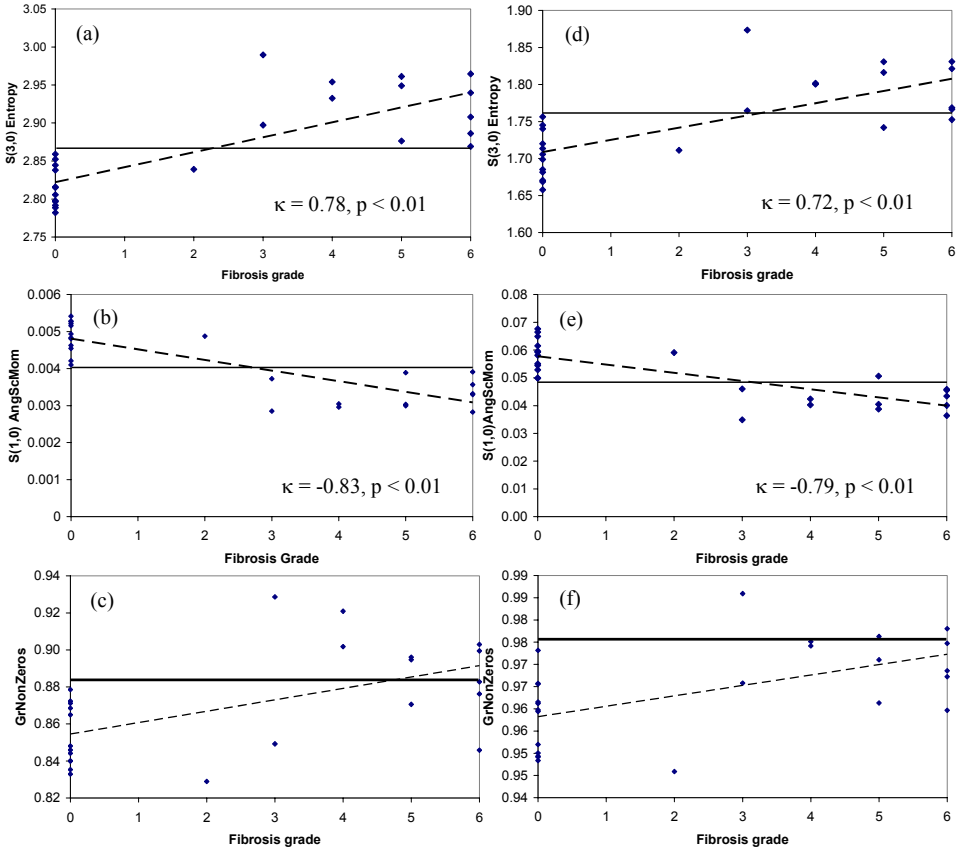

Figure 2: Plot of texture parameters against Fibrosis grade for healthy volunteers and patients for two of the identified texture measures: (a),(b) and (c) calculated using bin scheme A, (d),(e) and (f) calculated using bin scheme B on the high resolution T2w FRFSE data.