Baseline T2 MRI texture predicts visual recovery in patients with acute optic neuritis

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Introduction

Optic neuritis (ON) is a retrobulbar inflammatory injury that occurs frequently in the context of multiple sclerosis (MS). Optic nerve structure and function can be independently quantified, which makes it an ideal system model for MS to understand consequences of central nervous system (CNS) inflammation[1]. MRI texture analysis is a measure of the distribution pattern of image pixles. Preliminary data suggests that T2 MRI texture is a sensitive measure of tissue injury and recovery[2,3] and that the degree of coarseness of MRI texture relates to the severity of tissue injury in MS[4]. The goal of this study was to correlate MRI texture measures with other structural and functional assessments of vision, and to determine the relationship between MRI texture and visual recovery after ON.

Method

Fourteen patients (12 females; mean age of 36 years) with acute ON within 14 days of symptom onset were included in an ongoing prospective study. All subjects were imaged at a 3T scanner (GE Signa, WI) at onset (baseline) and at month 6 using an optic nerve dedicated protocol which included: sagittal T1 spin echo (SE), axial 3-dimentional fast SE, coronal precontrast and postcontrast fat-saturation T1 SE, and coronal short tau inversion recovery (STIR) MRI. T2 lesion length, gadolinium (Gd)-enhancing activity, and the area ratio (ON versus fellow eyes) of the optic nerve were evaluated using Osirix for Mac (version 3.6). Optic nerve regions of interest (ROIs) were obtained using a semi-automatic region-growing program in Osirix. T2 lesion texture was analyzed using a spatial-frequency based algorithm on the coronal STIR images which demonstrated the maximal lesion area. Pixel-wise texture maps were generated accordingly (Fig. 1), from which the texture of lesion ROIs was extracted. The retinal nerve fiber layer (RNFL) thickness assessed using optical coherence tomography (Zeiss Stratus III) and visual acuity measured as the logarithm of minimum angle resolution (logMAR) were obtained at identical timepoints. The relationships between structural variables and between structural and functional measurements were assessed using multiple regression analysis ($p \leq 0.05$ as significance).

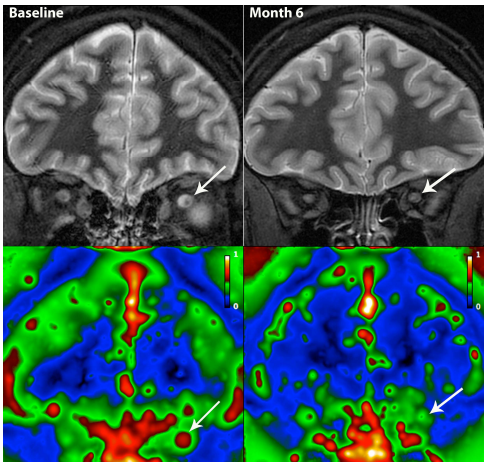

Fig1: The texture was coarser (red) in the ON eye (arrows) than in the fellow eye at baseline. It became finer as vision recovers at month 6.

Results

Acute lesions were seen in each of the ON eyes (mean length=14.2 mm) and in one fellow eye (4 mm). Nine/15 lesions demonstrated Gd-enhancement; all were located in the ON eyes. Relative to the fellow eye, there was a tendency for texture to be coarser (0.46 vs 0.38, $p=0.07$) and RNFL to be thicker (148 μm vs 86 μm, $p=0.09$) in the ON eye at baseline. Visual acuity was markedly decreased in the ON eye as compared to the fellow eye (0.5 vs 0.05, $p<0.01$) at disease onset, which correlated only with acute lesion texture ($p<0.01$). Furthermore, multiple regression analysis showed that lesion texture at baseline was the only parameter that correlated with visual recovery occurred over 6 months ($r=0.61$, $p<0.05$) (Fig. 2). As compared to baseline, vision improved by 0.49 ($p<0.01$), RNFL thinned by 26 μm ($p=0.03$), and lesion length decreased by 1.3 mm ($p=0.09$) on average in the ON eye over 6 months. There was minimal improvement in lesion texture (0.45 vs 0.46, $p=0.84$) and nerve area ratio (1.03 vs 1.09, $p=0.14$) during this period. The difference between ON and fellow eyes was smaller in each assessment ($p>0.05$) at month 6 and none correlated with logMAR after accounting for all the variances.

Discussion

This preliminary study suggests that MRI texture measured tissue integrity relates to acute vision loss, and predicts visual recovery after an acute inflammatory event in the anterior visual pathway: it outperforms conventional MRI and RNFL assessment. An acute inflammatory insult may involve several pathological processes including inflammatory infiltrates, demyelination, edema, and axonal injury[5] which can each contribute to the complexity of tissue structure and therefore heterogeneity of MRI texture. Thus, coarser texture suggests greater tissue damage. Indeed, lesion texture was coarser than the normal appearing white matter texture in the postmortem MS brain[4]. Similarly, the coarseness of MRI texture in acute MS lesions predicts their recovery 8 months later[2]. While further verification is required findings in this study may suggest that T2 MRI texture is a potential predictor of functional outcome after CNS inflammation. This could be important to identify recovery and evaluate treatment benefits in MS patients.

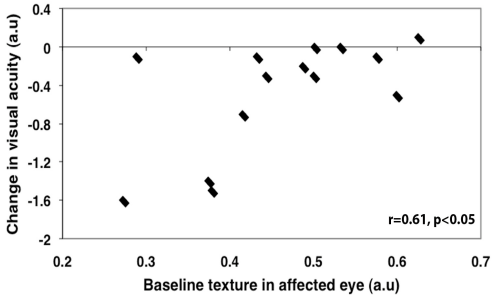

Fig2: Lesion texture at baseline predicts visual recovery 6 months after ON. A larger negative value represents greater recovery in vision.

References

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