Detecting Oligodendroglioma Genotype Non-Invasively Using MR Imaging

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Introduction

An early example of the practical application of molecular medicine to neuro-oncology was the recognition of the clinical relevance of 1p and 19q allelic loss in oligodendrogliomas.[1] 1p/19q deletion is strongly associated with response to chemotherapy, tumor control after radiotherapy and long-term survival, making identification of these tumors critical.[1] However, genetic diagnosis requires tissue to be recoverd via brain biopsy. In an effort to use imaging for non-invasive, early identification, a study was conducted by Megyesi *et al.* using radiologists to assess tumor appearance on MR images.[2] This qualitative study identified several significant features of 1p/19q-deleted tumors but failed to produce a diagnostic test. We have extended this work by applying and assessing a quantitative, computerized measurement of texture. Our study confirms that significant differences in appearance exist between 1p/19q deleted and intact oligodendroglioma and produces a diagnostic test with high sensitivity and specificity.

Methods

T2-, FLAIR- and T1+contrast-weighted MR images plus 1p/19q genetic status were acquired for 45 patients (24 1p/19q deleted, 21 intact) with histologically confirmed oligodendroglioma. The largest square ROI remaining entirely within definite tumor was drawn on each slice with greater than 50 contiguous tumor voxels, producing an average of 4,130 selected tumor voxels per patient. Images were resampled, if necessary, to a uniform in-plane resolution of 0.94 mm/pixel then cropped to a 128×128-pixel region around the tumor. An S-transform [3] was performed on each cropped image and the resulting two-dimensional local spectra for each voxel were collapsed by performing radial summation in order to produce one-dimensional voxel-specific spatial frequency spectra.[4] Spectra from each image type and tumors with and without 1p/19q deletion were compared using *t*-tests. Receiver operator characteristic (ROC) analysis [5] was performed for each frequency to assess its predictive power.

Results

Each of the T1+contrast-, T2- and FLAIR-weighted MR image groups displayed significant differences in the mid-frequency range between 1p/19q deleted and intact tumors. Of these, T2 had both the widest significant portion of spectrum (all frequencies between 0.058 and 0.467 cycles/mm) and the most significant frequency at 0.133 cycles/mm with $p < 0.001$. ROC analysis identified 0.233 cycles/mm from T2 images to be the feature with the best predictive value (sensitivity = 0.87, specificity = 0.90, positive predictive value = 0.91, negative predictive value = 0.86). This frequency also had the second most significant difference ($p < 0.001$). For comparison, the Megyesi study [2] found that radiologists performed with a sensitivity = 0.67 and specificity = 0.75.

Conclusions

We have presented a method for quantitative texture analysis based on local frequency spectrum and applied it to classification of oligodendroglioma, a task with considerable clinical importance. Our study has confirmed significant differences in the appearance of oligodendroglioma with and without 1p/19q deletion. In addition, texture analysis proved to be sensitive enough to form the basis for a diagnostic test with high sensitivity and specificity, using routinely acquired MR images.

Method	Contrast	Spatial Frequency (cycles/mm)	Sensitivity	Specificity	Significance of Difference
Computer	T2	0.233	0.87	0.90	p = 0.00013
	T1+contrast	0.058	0.75	0.75	p = 0.0037
	FLAIR	0.108	0.83	0.58	p = 0.023
Radiologist	Rating homogeneity on T1 and T2		0.67	0.75	p = 0.047

Table 1: *Comparison of texture analysis and assessment by radiologist for determining 1p/19q status from MR imaging. The first three rows indicate the best performing spatial frequency from each MR contrast studied, associated sensitivity and specificity and the significance of the difference in amplitude at that frequency (using a t-test). The last row details the performance of radiologists asked to assess tumor homogeneity [2].*

References

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