Predicting Recurrence Patterns of Gliomas Using Diffusion Tensor Imaging

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Background

Cerebral gliomas are malignant tumours with an appalling prognosis. Currently all patients receive the same treatment options which usually fail as surgery cannot completely remove them, radiotherapy doses have to be limited to avoid radiation necrosis to the surrounding normal brain and drugs penetrate them poorly. Yet we know that gliomas are among the most heterogeneous tumours with tumours of the same histological grade exhibiting differences in biology and clinical behaviour.

Previous work has shown that diffusion tensor can identify abnormalities surrounding gliomas and that image-guided biopsies confirm that these are due to tumour infiltration[1]. These abnormalities appear to occur before obvious tumour recurrence can be seen[2]. The aim of this study was to see if diffusion tensor abnormalities could predict the pattern of glioma recurrence.

Patients and Methods

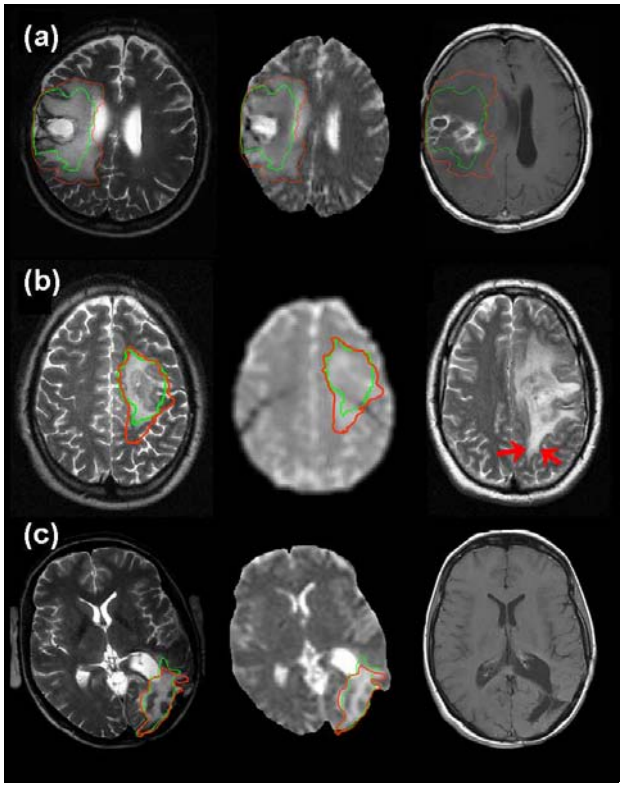
We studied 26 patients (mean age 44 years; 10 female) with histologically confirmed gliomas who had DTI studies as part of other research protocols. All patients had further imaging at recurrence or were high grade tumours with no evidence of disease progression for over a minimum of 2 years. Patients who underwent surgical debulking after the DTI study were excluded, but patients that had radiotherapy or chemotherapy were included in this study. 7 patients had no treatment between studies. All patients were imaged at 3 Tesla using a DTI sequence and a T_2-weighted/proton density FSE sequence. Some patients also underwent a post-contrast inversion recovery T_1-weighted sequence. The DTI data set was analysed using an in house program implemented in MATLAB to produce *p* (the isotropic component of the diffusion tensor) and *q* (the anisotropic component of the diffusion tensor)[3]. A region was drawn around the abnormality on the *q* map and this was superimposed on the *p* map. The difference between the lines was defined as the zone of tumour infiltration.

Results

Three patterns of *pq* abnormality could be identified:

1. ***Diffuse abnormality:*** in 13 patients we identified a pattern where the *q* abnormality (in green) was smaller than the *p* abnormality (in red) in all directions. In 12/13 cases the recurrence pattern was a diffuse enlargement of the whole tumour. An example is shown in Figure (a).
2. ***Localised abnormality:*** in 8 patients we identified a pattern where the *p* abnormality was larger than the *q* abnormality in one principle direction. In all cases the recurrence pattern was localised to the direction of this abnormality. An example is shown in Figure (b).
3. ***Minimal abnormality:*** in 5 patients the *q* abnormality was similar to the *p* abnormality suggesting there was little tumour infiltration. One patient did progress, but in 4 patients (2 GBM and 2 WHO Grade III gliomas) there has been little disease progression over a period of 2 – 5 years. An example is shown in Figure (c).

Overall this technique could predict the pattern of recurrence in 24/26 cases (92%). Similar patterns of recurrence were seen in patients treated with radiotherapy or chemotherapy compared to those that did not receive any treatment.



Discussion

Using this technique we can predict the pattern of glioma recurrence. Such techniques might allow us to better understand different tumour phenotypes to allow us to probe for molecular and genetic differences. It may also allow us to sculpt radiotherapy fields to increase the dose to areas most likely to cause recurrence and reduce the dose to normal brain. It may also allow us to direct local therapies such as convection enhanced delivery into the areas most likely to cause recurrence.

References

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