Correlation Between Magnetic Resonance Images and Histology in Meningiomas: T2-weighted Images Indicate Collagen Contents in Tissues

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Abstract

The magnetic resonance imaging appearance of 40 surgically confirmed intracranial meningiomas was reviewed to correlate signal intensity on T2-weighted images with histological subtypes of meningioma. A moderate variation of signal intensity was found within a given histological subtype. The mean signal intensity scores on T2-weighted images of the fibrous type of meningioma were significantly lower than those of the other types, and were correlated with the collagen content. The signal intensity of meningiomas on T2-weighted images crudely predicts the histological type. Tumors significantly hypointense compared to the cortex are composed primarily of fibrous elements.

Key words: histology, meningioma, magnetic resonance imaging

Introduction

Magnetic resonance (MR) imaging can demonstrate anatomical relationships and is more sensitive than computed tomography (CT) for the detection of a wide range of intracranial pathologies.1-3) The correlation between MR imaging appearance and histology of meningiomas has frequently been investigated. In general, T1-weighted images are not useful for differentiating subtypes of meningiomas,6 but there is no consensus about the usefulness of T2-weighted images. This retrospective study attempted to determine whether there is a correlation between the signal intensity on the T2-weighted images and the histology of meningiomas.

Patients and Methods

Forty patients (20 males and 20 females; mean age 51 yrs) with surgically confirmed meningiomas underwent MR imaging. All meningiomas were classified histologically according to the World Health Organization classification12) into six fibrous, nine transitional, 18 meningothelial, two angiomatous, two psammomatous, and three anaplastic type meningiomas.

MR images were taken with fields of 0.5 and 1.5 Tesla. T1-weighted images were obtained with the spin-echo (SE) sequence (600/200 msec), and T2-weighted images with the SE pulse sequence (2500/30/90 msec).

The visual scoring system proposed by Elster et

Table 1 Criteria for intensity scoring on T2-weighted images

<table>
<thead>
<tr>
<th>Score</th>
<th>Features</th>
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<tbody>
<tr>
<td>1</td>
<td>markedly hypointense compared to the cortical gray matter, nearly as dark as the cortical bone</td>
</tr>
<tr>
<td>2</td>
<td>mildly hypointense compared to the cortical gray matter, but easily distinguishable</td>
</tr>
<tr>
<td>3</td>
<td>nearly isointense with the cortical gray matter, may be difficult to distinguish</td>
</tr>
<tr>
<td>4</td>
<td>mildly hyperintense to the gray matter, easily distinguished</td>
</tr>
<tr>
<td>5</td>
<td>markedly hyperintense to the gray matter, nearly as intense as CSF</td>
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</tbody>
</table>

According to Elster et al.7) CSF: cerebrospinal fluid.
al.) was used for the T2-weighted images. Table 1 shows the criteria used for scoring. Elster scores for each individual tumor were assigned independently by four readers separately who were blinded to the histology of the meningiomas. Each reader was asked to score the apparent signal intensity of each meningioma relative to that of cortical gray matter on the T2-weighted images. We then calculated the mean score for each tumor and compared the assigned Elster scores for the meningioma subtypes.

Sections (4 μm) of formalin-fixed, paraffin-embedded tissues from the six fibrous type meningiomas were stained with Elastica van Giesson stain and the percentage of collagen (collagen positive area/total area) was estimated using image analyzing software (NIH Image™; NIH, Bethesda, Md., U.S.A.). The correlation between the Elster scores and the collagen content of tumors was then evaluated.

Student's t test for paired data was used to determine the statistical significance of differences between the Elster scores for each meningioma type. Linear-regression analysis was used to correlate the Elster score and the percentage of collagen in fibrous type tumor tissue.

**Results**

T2-weighted MR imaging showed 18 meningiomas as essentially isointense (Elster score 2.5-3.5), six as hypointense (score < 2.5), and 16 as hyperintense (score > 3.5) compared to the cortical gray matter. There was a moderate variation of signal intensity within a given histological subtype (Fig. 1). The meningothelial type had a mean score of 3.65 ± 0.91 (SD) and only one was hypointense (Fig. 2). The transitional type had a mean score of 3.11 ± 0.45 and one was hypointense. In contrast, the fibrous type had a mean score of 2.33 ± 0.5 and three were hypointense (Fig. 3). Statistical analysis of the scores for all possible pairs of the six histological subtypes confirmed that the fibrous type had a significantly lower score than the other types (p < 0.01). There

![Fig. 1 Correlation between Elster scores and subtypes of meningioma. The points represent the mean score for each tumor. Bars show mean value ± SD for each group.](image)

![Fig. 2 T2-weighted MR image showing a right occipital meningioma as isointense with a score of 3.0 (left). Photomicrograph showing the tumor is a meningothelial meningioma (right: HE stain, ×100).](image)
were no significant differences between the other subtypes. The scores of psammomatous, anaplastic, and angiomatous types tended to be high. The tumor signals on the T1-weighted images were very similar regardless of the histological type (data not shown).

The percentage of collagen in the six fibrous meningiomas was compared with the scores for the individual tissues. The percentages of collagen in the isointense group (n = 3, mean score 2.8) and the hypointense group (n = 3, mean score 1.8) of fibrous meningiomas were 6.9 and 17.4, respectively, and this difference was significant (p < 0.01). Linear regression analysis revealed that the score and the collagen content were closely correlated: y = 33.9 - 9.33x (p < 0.005) (Fig. 4).

**Discussion**

Previous attempts to predict the histological type and malignancy of meningiomas have used angiography, scintigraphy, and CT. Kendall and Pullicino and Vassilouthis and Ambrose attempted to correlate CT findings of meningiomas with tumor pathology. Farkas et al., who reviewed 32 cases, were unable to discern distinguishing features in their radiologic and angiographic studies that would permit the identification of meningioma subtypes. In contrast, Kendall and Pullicino found that hard meningioma tended to show increased attenuation compared to soft meningioma.

The MR imaging appearance of intracranial meningiomas has been extensively investigated, but attempts to correlate signal intensity with histology have achieved varying success. Spagnoli et al. studied 25 meningiomas and found no correlation between MR imaging appearance and their pathological classification, although psammomatous meningiomas tended to be less intense on T2-weighted images. Elster et al. reported that although T1-weighted images were not particularly useful in distinguishing histological subtypes, T2-weighted images were strongly correlated with histological findings in over 75% of cases. They concluded that the signal intensity of meningiomas on T2-weighted images can crudely predict the histological type. Tumors that were markedly significantly hypointense compared to the cortex tended to be composed primarily of fibrous elements. Chen et al. also found that fibrous menin-
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Giomas with attenuated cells embedded in a dense collagenous matrix are hypointense on T2-weighted images. However, Demaerel et al.\(^6\) using the visual scoring system proposed by Elster et al.\(^7\) found that many fibrous and transitional meningiomas, and all psammomatous meningiomas were hyperintense compared to the cortex, and concluded that it is impossible to differentiate the different subtypes on the basis of T2-weighted images. Carpeggiani et al.\(^4\) also found no statistical correlation between signal intensity and histology in intracranial meningiomas.

Our findings using the Elster scoring method coincided with those reported by Elster et al.\(^8\) and Chen et al.\(^9\) Meningiomas that were markedly hypointense compared to the cortex on T2-weighted images were composed predominantly of fibrous elements, while hyperintense meningiomas demonstrated psammomatous or angiomatous features.

Hirai et al.\(^10\) reported that the difference in the signal intensity between subtypes of meningiomas on T2-weighted images is mainly related to the water content of tissues. Fibrous meningiomas are composed of interlacing bundles of long, narrow spindle cells in a dense collagenous matrix.\(^12\) Typical fibrosis and fibrous tumors in other parts of the body also exhibit low signal intensity on T1- and T2-weighted images.\(^9\) Therefore, the tissue collagen content is probably responsible for the present finding.

We conclude that the signal intensity of meningiomas on T2-weighted images is correlated with, and crudely predicts the histological type, and that tumors appearing significantly hypointense compared to the cortex are composed primarily of fibrous elements.

References


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