1H-MRS metabolic patterns for distinguishing between meningiomas and other brain tumors

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Abstract

Yet meningiomas have characteristic neuroimaging features, some other lesions are still confusing with meningiomas. The aim of this study was trying to find the typical 1H-MRS metabolic factors of histologic subtyped meningiomas, schwannomas, metastases, and other brain tumors for differential diagnosis among them. 1H-MRS using STEAM (TE/30 ms, TR/2 sec) and PRESS (TE/288 ms, TR/2 sec) sequences were performed on 44 untreated brain tumors. Obtained metabolic patterns from the typical spectra of meningioma, schwannoma, metastasis were compared with each other or other brain tumors to evaluate the usefulness for diagnosis between them. Alanine (Ala) was observed in 15 cases of the 19 meningiomas with a little variation to three histologic subtypes, while minimal lipids were observed in every 19 meningiomas. Elevated glutamate/glutamine (Glx) was detected in 12 cases of the meningiomas. Increased myo-inositol (mI) was detected in 11 cases of the 13 schwannomas. Dominant lipids signals as well as long-T2 lipids were detected in every metastasis in conjunction with elevated choline (Cho). Enhanced Glx was observed in 4 cases of the 8 metastases without correlation of primary tumor site or types. Hemangiopericytoma showed different spectral patterns from typical meningiomas: only dominant Cho, minimal lipids and absence of Ala or Glx signals. These metabolic patterns in typical tumors may provide a basis for differential diagnosis (average value of $\chi^2 = 23.33$, $p < 0.01$) between meningiomas and schwannomas as well as metastases. However proton spectral distinction among the different histologic subtypes of meningiomas was not definite. © 2003 Elsevier Inc. All rights reserved.

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1. Introduction

With advent of MRI, the quality of preoperative diagnostic imaging for meningiomas have been improved dramatically and most of cases it is not difficult to diagnose meningiomas with conventional MRI with gadolinium-DTPA enhancement. With current MR imaging technique, dural attachment, sinus involvement and even information about a histologic subtype, vascularity and tumor’s consistency are possible. [1] Yet meningiomas have characteristic neuroimaging features, some other lesions are still confusing with meningiomas. Especially it is not easy to distinguish menigiomas from hemangiopericytomas, schwannomas occurring at the cerebello-pontine angle, dural metastatic tumors mimicking meningiomas. Surgical procedures or therapeutic plan of each tumorous condition may be quite different depending on the preoperative impression. [2] When diagnosing atypical tumor or tumor-like transformation, and preoperative diagnosis is not confident just by using conventional MRI and even using contrast-enhanced MRI methods, it is frequently requested to rule out meningiomas unambiguously. In addition the more detailed identification of the subtype of meningiomas may provide valuable information prior to surgical planning.

Studies of extracts of surgical specimens have generally indicated an increase in Alanine in meningiomas and an increase in myo-inositol in schwannomas. [3,4] Elevation of Glx were observed in the extracts of surgically excised samples of meningiomas [5] and in an in vivo study. [6] However these findings have been still controversial without extended in vivo studies with multiple cases of meningiomas or schwannomas. In vivo MRS studies of human metastasis show a similar correlation between metabolic features and histopathological grade. Lactate was more
likely to be present in late stage than in early or intermediate stage metastasis. [7,8] Lipid was recognized to occur in tumors of higher histopathological grade, [8] and was correlated with the amount of microscopic cellular necrosis. [7,9] However at present MRS cannot reliably characterize histologic types or subtypes of tumors in the clinical routine as the metabolic patterns seen in vivo MRS are not sufficiently correlating to histologic diagnosis.

In this study localized proton spectroscopy was investigated on the untreated tumors diagnosed as meningiomas, schwannomas, metastases and other brain lesions by only the MRI basis, which were substantially confirmed with biopsy. We evaluated the potential significance of MRS findings of new metabolic markers in the pre-operative differential diagnosis of these brain tumors. Spectral characteristics of meningiomas were investigated according to the histologic subtypes retrospectively.

2. Materials and methods

2.1. Patients

Forty-five untreated brain tumors were examined by 1H MRS. Meningioma \((N = 19)\), schwannomas \((n = 13)\), metastases \((n = 8)\), hemangiopericytoma \((n = 3)\), osteosarcoma \((n = 1)\) were included in the examined patients. Histologic types of tumor were confirmed by intraoperative biopsy after obtaining proton MR spectra.

2.2. MRI methods

Localizing imaging was obtained by T1-weighted \((\text{TR/TE}:489/15, \text{two NEX, matrix size 256 } \times \text{ 192})\) and T2-weighted images \((\text{TR/TE}:3500/98 \text{ ms, one NEX, matrix 256 } \times \text{ 224})\) using spin echo and fast spin echo sequences, respectively, at GE Signa 1.5 T clinical MR unit.

2.3. Proton MR spectroscopy

A volume of interest of 1.0 to 8.0 mL was selected from the center of the lesion with edges of the voxel well within the mass, and the field homogeneity achieved in local shimming resulted in water peak line widths of typically 2-4 hz. Localized single voxel proton MR spectroscopy was performed using stimulated echo acquisition mode [10] (STEAM, TE/TR, 34 ms/2000 ms) and point resolved spectroscopy [11] (PRESS, TE/TR, 272 or 288 ms/2000 ms) with three chemical shift selective pulses (CHESS) and subsequent spoiling gradient for water suppression. The bandwidth of the CHESS pulses was 60–75 hz. The second half of the spin echo was collected using 2048 data points, a spectral width of 2000 hz, 128 acquisitions typically. Time domain data, transferred to SUN workstation and processed with SAGE software from MRI manufacture, were zero filled to 4096 points, multiplied with exponential or Gaussian exponential function (line broadening, typically 1.5–4.5 hz), Fourier transformed, phase corrected and referenced to residual water resonance at 4.77 ppm. Baseline was corrected with linear tilting algorithm in some cases.

Relative peak heights, Cr/Cho and ml/Cho, were estimated in meningiomas and schwannomas, respectively. Other metabolic peaks were compared with those of normal brain tissues in the literatures. [12,13] Significance of metabolic factors of each tumors in differentiation was estimated with \(\chi^2\) test for evaluating homogeneity.

3. Results

3.1. Typical spectral patterns of meningioma

There was a marked reduction in NAA in every meningiomas, while marked reduction of Cr occurred in only 50% cases of the examined meningiomas. Observed 1H NMR spectral patterns were described in Figs. 1–2, and summarized in Table 1. Relative peak height ratio \([\text{Cr/Cho}]\) was estimated. Detection of some amino acids resonances, such as elevated Glx or Ala, was most notable. Ala resonance was detected at 1.55 ppm in 15 cases of all 19 patients. In addition elevated Glx resonances were observed in 12 cases. Both resonances were detected simultaneously or alternatively in every meningiomas except two cases. Secondly lipids were not observed or detected with minimal amount compared to other brain tumors. In the PRESS spectra with a long-TE (272 or 288 ms), a resonance around 3.8 ppm was consistently revealed in many maningioma irrespective of histologic variation even though manitol, resonating around 3.85 ppm, was not applied at the time of measurements except two cases. This resonance was not observed in hemangiopericytoma, schwannomas as well as metastases. This signal was currently not assigned clearly.

3.2. Typical 1H spectral patterns of schwannomas

Observed 1H NMR spectral patterns of schwannomas were described in a typical spectrum (Fig. 3) that showed the common patterns with general metabolic behavior of brain tumor and also a characteristic signal elevation at 3.56 ppm. Elevated Cho and reduction in NAA and Cr were commonly observed. Relatively large lipids were detected in 7 cases of schwannomas. Elevated signal at 3.56 ppm, representing ml, was observed in 12 cases of the 13 patients. This elevation of ml was estimated in terms of the peak height ratio, ml/Cho. Averaged value of this ratio was 1.15 with a distribution in the range of 0.83-1.43, while the ratio has been reported 0.67–0.75 in normal brain tissue. [12,13] The resonance around 3.8–4.0 ppm was observed consistently in the short-TE STEAM spectra even though Cr and Glx were minimal while it was absent in long-TE PRESS spectra. Manitol was not used for those patients at the time of MRS measurements.
3.3. Typical $^1$H spectral patterns of metastasis

Observed $^1$H NMR spectral patterns of typical metastasis were represented in Fig. 4. Dominant lipids were detected in all cases. Lactate was observed in the late stage of tumor. Also Cho was highly enhanced while NAA and Cr were almost absent. Interestingly relatively enhanced Glx resonance, which was almost comparable with the intensity of Cho, were observed in 4 cases of all eight patients.

3.4. $^1$H-NMR spectra of other brain tumors

A $^1$H-spectrum of hemangiopericytomas was shown in Fig. 5. A dominant Cho was observed with little of lipids and without enhanced Glx or Ala in two cases. In the other case additional resonances at 3.40 and 3.56 ppm were detected as well resolved peaks. The resonance around 3.8 ppm, observed in long-TE PRESS spectra of meningiomas, was not detected in the spectra of hemangiopericytomas. The spectrum from an Osteosarcoma showed the presence of only broad lipids signals. This observation was compared with the spectrum of a metastasis which occurred at similar anatomic region (see Fig. 6).

3.5. Statistical analysis

Table 2 summarized statistical occurrence and $\chi^2$ test of metabolic factors in meningiomas, schwannomas and metastasis which may provide a potential basis for differential diagnosis between them. In the comparison of meningiomas with schwannomas all listed metabolic factors except long-T2 lipids were confident in differentiation between two
groups with \( p < 0.01 \) or 0.05. When comparing meningiomas with metastasis, other metabolites than elevated Glx or increased mI showed their significance in differentiation between two groups with \( P \) values less than 0.01 or 0.05.

4. Discussions

4.1. Meningiomas vs. schwannomas

Previous studies of other laboratories reported a marked reduction of both the N-acetylaspartate (NAA) and phosphocreatine (PCr)/creatine (Cr) peaks in meningioma [14]. It was reported that this reduction was greater than that seen in astrocytoma. Reduction in or absence of NAA expressed the absence of neurons and axons from most tumors, which are histologically derived from astrocytes, which entirely lack NAA (glioma), connective tissue (meningiomas), or from remote tissues of nonneuronal origin (virtually all secondary tumors). Although the marked reduction of the PCr/Cr peak in meningioma has been reported by in vivo \(^{31}\)P-MRS [16] and in vitro \(^1\)H-MRS, [5] as well as biochemically, [15] it occurred only in 50% of the time in this study as demonstrated on the estimated ratio Cr/Cho in Table 1. This ratio distributed in the range of 0.9–1.3 in normal brain tissue. [12,13] As shown in Fig. 1b and Table 1, it was not

![STEAM spectrum of a meningiomas: fibrous type. Elevated Glx were resonating at 2.0–2.4 ppm and around 3.8 ppm in STEAM spectrum while marked reduction of Cr occurred when compared to Fig. 1b.](image)

<table>
<thead>
<tr>
<th>Table 1</th>
<th>(^1)H-NMR spectral patterns of meningiomas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meningothelial</td>
<td>Cho</td>
</tr>
<tr>
<td>Pat. 1</td>
<td>+</td>
</tr>
<tr>
<td>Pat. 2</td>
<td>+</td>
</tr>
<tr>
<td>Pat. 3</td>
<td>+</td>
</tr>
<tr>
<td>Pat. 4</td>
<td>+</td>
</tr>
<tr>
<td>Pat. 5</td>
<td>+</td>
</tr>
<tr>
<td>Pat. 6</td>
<td>+</td>
</tr>
<tr>
<td>Pat. 7</td>
<td>+</td>
</tr>
<tr>
<td>Pat. 8</td>
<td>+</td>
</tr>
<tr>
<td>Pat. 9</td>
<td>+</td>
</tr>
<tr>
<td>Fibrous</td>
<td>Pat. 10</td>
</tr>
<tr>
<td>Pat. 11</td>
<td>+</td>
</tr>
<tr>
<td>Pat. 12</td>
<td>+</td>
</tr>
<tr>
<td>Pat. 13</td>
<td>+</td>
</tr>
<tr>
<td>Transitional</td>
<td>Pat. 14</td>
</tr>
<tr>
<td>Pat. 15</td>
<td>+</td>
</tr>
<tr>
<td>Pat. 16</td>
<td>+</td>
</tr>
<tr>
<td>Pat. 17</td>
<td>+</td>
</tr>
<tr>
<td>Psammomatous</td>
<td>Pat. 18</td>
</tr>
<tr>
<td>Microcystic</td>
<td>Pat. 19</td>
</tr>
<tr>
<td>Hemangiopericytoma</td>
<td>Pat. 20</td>
</tr>
<tr>
<td>Pat. 21</td>
<td>+</td>
</tr>
<tr>
<td>Pat. 22</td>
<td>+</td>
</tr>
</tbody>
</table>

++ elevated, + present, – absent, na PRESS spectrum was not available

* unknown signal at 3.8 ppm in long-TE PRESS spectrum

* Peak height ratio representing marked reduction of Cr in meningioma. In normal tissue it distributes in the range of 0.9–1.3.
reasonable to regard the cases with the ratio greater than 0.4 as marked reduction of Cr. It appeared from in vivo phosphorus MRS [16] and in vitro $^1$H-MRS [5] studies that Cho in meningiomas was increased only slightly (1.1 times the normal control value) or not at all whereas it was quite enhanced (1.9 times the normal control value) in schwannomas. However the amount of such alteration between two tumor types was not evident from this in vivo study since absolute quantification was not available. On the other hand elevated Cho was nearly always observed and has been substantiated by chemical assays on tumor biopsies. Therefore elevated Cho does not merely represent the increased membrane synthesis of rapidly proliferating cell but also breakdown of NMR-invisible phosphatidylcholine, releasing NMR-visible cholines in a viable brain tumor irrespective of malignancy.

Ala, an alternative reduced partner of pyruvate derived from glycolysis, have been observed frequently in meningiomas [17,18,19], and also detected in 15 cases of the meningiomas from this study. Elevated Glx, which has been reported already from other studies [6,17], was detected in 12 cases of the meningiomas in this study where lactate was detected at the same times except one case. It suggested transamination pathway and partial oxidation of glutamine rather than glycolysis in the metabolism of meningiomas. Higuchi et al. [4] reported an increase in Ala and Glx in rats subjected to transient global ischemia. Thus it may be related to pathologic condition of meningiomas, such as tumor necrosis and hypoxia, at the time of measurements.

Elevated ml was observed in almost every examined schwannomas. Detection of enhanced ml have been reported from in vitro $^1$H MRS [5] and in vivo $^1$H MRS [20] studies. Myo-inositol, significantly accumulated in the undifferentiated state of cells, [21] has been considered in its role as an osmolyte and astrocyte marker, rather than as the neural messenger.
Ala and/or elevated Glx or elevated mI were notable landmarks for differential diagnosis between two tumor types as indicated in Table 2. In this study of meningo mas Ala and enhanced Glx was alternatively or simultaneously observed in every case except two patients. In case those two signals were not exactly identified simultaneously, the lipids around 0.0–2.0 ppm would be a useful metabolic factor for diagnosis. Lipids resonances were observed as only minimal always in the meningiomas while relatively enhanced in the schwannomas. Another metabolic candidate for diagnosis was an unidentified resonance at 3.8 ppm revealed in every available long-TE PRESS spectra (see Fig. 1-c.) of the examined meningiomas while absent in other brain tumors of in this study including schwannomas. This may suggest the presence of unknown metabolite in meningiomas. Very recently the elevated glutathione in meningiomas was shown to contributing to the $^1$H spectra of meningiomas at the resonances around 2.36, 2.9, 3.4 and 3.78 ppm. [22]

There were three cases which were diagnostically ambiguous between meningiomas and schwannomas or which were difficult to rule out meningiomas with MRI alone. Ala and/or enhanced Glx were found in two such cases, while increased mI was observed without Ala or enhanced Glx in one case. These metabolic factors were potentially useful in clinical differential diagnosis as implicated in their statistical significance (see Table 2).
4.2. Meningiomas vs metastases

If the clinical history is typical and lesions are multiple, little doubt usually surrounds the diagnosis. Because the treatment is different, single metastases must be differentiated from benign or malignant primary brain tumors, abscesses, cerebral infarcts and hemorrhages. Contrast-enhanced magnetic resonance imaging is more sensitive than either enhanced computed tomography or unenhanced magnetic resonance imaging. One study has shown that the false-positive rate for the diagnosis of a single brain metastasis is approximately 11%, even if contrast magnetic resonance imaging is used [23]. The second most frequent meningeal lesions are metastasis, which from an imaging point of view are difficult to diagnose from meningiomas. Both these tumoral forms can uptake MRI contrast agent in a similar manner and thus hinder differential diagnosis.

Decreased creatine was inconstant finding in tumors. When present it has usually been ascribed to the low energy status of glycolysing tumors in general. In the case of secondary tumors the explanation is more straightforward, since most tissues that commonly metastasize to brain lack both PCr and creatine kinase. But the reduction of Cr was not the metabolic factor for differential diagnosis between metastasis and other primary brain tumors.

Large lipids resonance of metastasis was conspicuous mark to distinguish metastasis from meningiomas in which those signals were minimal or absent. Usually lipids peaks are overlapped with lactate resonance. Long-TE PRESS spectrum was helpful to resolve them by decaying out lipids with T2-relaxation effect while retaining in-phase lactate signal. However the long-T2 lipids were observed as mixed form with lactate doublet or lipid singlet alone at 1.3 ppm even in long TE-PRESS spectra of metastasis. Lipid signals commonly associated with tumor spectra have usually been ascribed to necrotic regions, in untreated tumors, or to

![Fig. 5. FSE T2-weighted imaging (a), STEAM (b), and PRESS (c) spectra of a hemangiopericytoma. Dominant choline was detected in STEAM spectrum, which showed relatively simple spectral pattern in comparison with meningiomas. Only choline resonance was observed at long echo-time PRESS.](image-url)
treatment responsive necrosis in treated tumors. [7,9,18,24]
As necrotic tumor and viable tumor have shown different spectral patterns with only large lipids and Cho/large lipids, respectively. [7] The latter was always observed in Fig. 6. FSE T2-weighted imaging (a), STEAM (b) spectrum of an osteosarcoma. FSE T2-weighted imaging (c), STEAM (d) spectrum of a metastasis. Contrasting spectral features were observed in two brain mass regions. None of tissue signals were detected in STEAM spectrum of (b).

Table 2
The occurrence of metabolites in the three types of tumors and their chi-square test results for differential diagnosis between them

<table>
<thead>
<tr>
<th>Metabolic Factors</th>
<th>Meningiomas [19 cases]</th>
<th>Schwannomas [11 cases]</th>
<th>Metastasis [8 cases]</th>
<th>Mg vs Sch $\chi^2$(p)*</th>
<th>Mg vs Mt $\chi^2$(p)†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ala</td>
<td>15/19</td>
<td>0/11</td>
<td>0/8</td>
<td>17.368(0.000)‡</td>
<td>14.211(0.000)</td>
</tr>
<tr>
<td>Glx ↑</td>
<td>12/19</td>
<td>0/11</td>
<td>4/8</td>
<td>11.579(0.010)</td>
<td>0.404(0.525)</td>
</tr>
<tr>
<td>Glx ↑/Ala</td>
<td>10/19</td>
<td>0/11</td>
<td>0/8</td>
<td>8.684(0.030)‡</td>
<td>6.687(0.010)</td>
</tr>
<tr>
<td>Little lipids</td>
<td>19/19</td>
<td>4/11</td>
<td>0/8</td>
<td>15.771(0.000)</td>
<td>27.000(0.000)</td>
</tr>
<tr>
<td>Signals* at 3.8 ppm</td>
<td>13/13</td>
<td>0/11</td>
<td>0/8</td>
<td>13.282(0.000)</td>
<td>10.556(0.001)</td>
</tr>
<tr>
<td>Myo-Inositol ↑</td>
<td>0/19</td>
<td>10/11</td>
<td>0/8</td>
<td>25.909(0.000)</td>
<td>0.000(1.000)</td>
</tr>
<tr>
<td>long-T2 lipids</td>
<td>0/13</td>
<td>1/11</td>
<td>8/8</td>
<td>1.787(0.367)</td>
<td>27.000(0.000)</td>
</tr>
</tbody>
</table>

* meningiomas vs schwannomas, ‡ meningiomas vs metastasis
* unknown signals in long-TE PRESS spectra
‡ P < 0.01, † P < 0.05
every metastatic tumors of this study. Triglycerides, a form of lipid, was frequently encountered in the MR spectra of active growing tumors, and could be derived from membrane or myelin-lipid breakdown without cell necrosis. [7,25] Observation of Cho and long-T2 lipids simultaneously in active growing tumors may suggest its attribution also to increased phospholipids metabolism in highly proliferating cells since increased PDE was shown in high grade brain tumors from P31-MRS studies. [16,26] Triglycerides may play a role as source of lipids turn over in this metabolic pathway. Such long-T2 lipids were not detected in meningioma or schwannomas. However this observation can be argued in case of early staged metastatic tumor where increased Cho was observed without lipids or significant lactate. Hence in metastases, presence of long-T2 lipids did not merely represent the status of necrotic tissue but would indicate rapid tumoral growth as a kind of malignancy factor as discussed in other literatures. [7,8,25] Unusual resonance revealed around 3.8 ppm in long-TE PRESS spectra of meningiomas were not detected in metastases.

Interestingly, enhanced Glx as much intensity as Cho was also observed in 4 cases of metastases. This may provide additional information for differential diagnosis between glioblastoma multiforme and metastasis. Usually Glx is increased in hypoxic, ischemic, or recovering brain. However this observation was not correlated with a specific type or source of primary tumor. The primary tumors which related to corresponding metastasis exhibiting increased Glx were scattered over lung carcinoma, stomach cancer, rectal cancer and hepatoma. The metastatic site also did not show any constancy. Three cases were metastasized intracranially while one was in posterior fossa. This will be investigated in further studies. Observed spectral patterns of metastasis and meningiomas demonstrated a contrast clearly between metastasis and meningiomas in most cases. This was statistically significant with \( p < 0.01 \) when considering metabolic factors such as Ala, little lipids, unidentified signal at 3.8 ppm and long-T2 lipids.

There were two cases with single lesion. In one it was diagnosed as primary tumor including meningiomas with MRI alone. Large lipids and enhanced Glx were observed simultaneously. Meningiomas was ruled out and diagnosed as a metastasis with MRS findings which was confirmed later by biopsy.

4.3. Subtypes of meningioma

There is increasing interest in using MRI characteristics to tissue-subtype meningiomas preoperatively. The results of these studies have been varied, with studies reporting 75-96% accuracy and others finding no correlation. [27,28] Specifically, meningothelial and angioablastic variants were found to have a persistently higher signal intensity on T2-weighted images than fibroblastic and transitional meningiomas, [27] reflecting microscopic hypervascularity and soft tumor consistency. The amount of cerebral edema present in association with the meningiomas was also found generally to be greater when meningothelial or angioablastic variants were present. However the metabolic patterns of meningiomas appeared to be irrespective of different subtypes of meningiomas as represented in Table 1. Ala was observed in all fibrous subtypes \((n = 4)\) of meningiomas while not detected in some other groups. Its level was relatively large in transitional and fibrous types whereas minimally observed in meningothelial type. Enhanced Glx resonances were observed in every fibrous type while it was not always detected among the other groups. Therefore it was not straightforward to classify histologic subtypes of meningiomas just on the basis of \(^1H\) NMR spectra alone at this moment.

4.4. Hemangiopericytomas vs meningiomas

Three cases of hemangiopericytoma were originally diagnosed as meningiomas based on MR imaging. This variant of angioablastic meningiomas is histologically characteristic which shows the highly cellular nature of neoplasm, with polygonal cells separated by thin-walled vascular spaces. Its spectral patterns differed from those of meningiomas in a number of facts. In the two cases a dominant choline was observed with little of lipids and without Ala or enhanced Glx (Fig. 5). In the other case additional two resonances at 3.4 and 3.56 ppm were detected with well resolved peaks. The both resonances were also observed in long-TE PRESS spectrum. This suggested that these peaks were not glucose or myo-inositol which has short T2-relaxation time, 110 ms. It may be a coupled spin resonance from a single unknown molecule. Absent lipids and minimal lactate were similar to the spectral patterns observed in meningiomas. The resonance around 3.8 ppm occurred in long-TE PRESS spectra of meningiomas was not detected in the spectra of hemangiopericytomas. This unknown signal may be potential metabolic marker for differential diagnosis between two types of tumors in particular when neither Ala nor elevated Glx was detected.

4.5. Osteosarcoma case to rule out meningiomas or metastasis

A case was introduced originally to rule out meningioma as shown in Fig. 6a. MRS demonstrated only broad lipids in short-TE STEAM spectrum without any other tissue signals. There was no lipid in long-TE PRESS spectrum. This case was compared with a metastasis occurred in the very similar location (Fig. 6a–d). Comparison of both spectra suggested that this tumor was not the meningiomas or metastasis. Post-op biopsy result reported it as osteosarcoma.
5. Conclusions

Alternative or simultaneous observations of Ala, elevated Glx, minimal lipids and the resonance at 3.8 ppm in meningiomas appeared to be potential metabolic factors for discriminating other brain tumors. Enhanced ml in schwannomas and long-T2 lipids of metastases may provide another information for the differential diagnosis from others. Enhanced Glx observed in a couple of metastases was not correlated to primary tumor types or tumor site. However it remains to be elucidated with further studies. It was not straightforward to classify the histologic subtypes of meningiomas on the basis of proton MR spectra that showed not clear distinction at this moment. Present study may suggest that acquiring both short-TE STEAM and long-TE PRESS spectra would increase metabolic information for differential diagnosis of brain tumors on the basis of 1H-NMR spectra.

References