Feasibility of Proton Chemical Shift Imaging with a Stereotactic Headframe

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Abstract
To prove feasibility of proton chemical shift imaging (1H CSI) during stereotactic procedure, authors performed 1H CSI in combination with a stereotactic headframe and selected targets according to local metabolic information, evaluated the pathologic results. The final pathologic results obtained were concordant with the local metabolic information from 1H CSI. We believe that 1H CSI-directed stereotactic biopsy has the potential to significantly improve the accuracy of stereotactic biopsy targeting.

Introduction
The appropriate treatment of intra-axial lesions under most circumstances requires a definite tissue diagnosis. The diagnostic yield of stereotactic biopsies depends upon sampling the most representative regions of the masses. Various strategies have been described for sampling the most reliable regions of masses [1, 2]. In a previous report that used 1H MRS for stereotactic biopsy target selection, the 1H MRS study was performed preoperatively, and independently of the stereotactic biopsy and single voxel study was done [2]. The authors studied the feasibility of 1H CSI with a stereotactic headframe in place and evaluated the reliability of 1H CSI-directed stereotactic biopsy.

Materials and Methods
The 1H CSI directed stereotactic biopsy was performed in five patients. 1H CSI-directed stereotactic biopsies were performed on a 1.5-T MR imager (Vision plus; Siemens, Erlangen, Germany) with a standard birdcage head coil. After application of stereotactic headframe (Leksell model G, Atlanta, Georgia) with local infiltration of lidocaine, the patients were taken to the MR unit. 1H CSI was performed before conventional stereotactic MRI with gadolinium enhancement for stereotactic coordinates. 1H CSI raw data were achieved using the multi-voxel PRESS sequence (1500/135 [repetition time, msec/echo time, msec], 180 flip angle, 4-mm section thickness, voxel size = 15 x 15 x 15 mm, 16 x 16 phase-encoding steps, field of view (FOV) = 240 mm, and 4 acquisitions). The postprocessing procedures included apodization with a hamming filter, a two-dimensional Fourier transformation, phase and baseline correction, and acquisition of peak areas by fitting to a summation of gaussian functions. The metabolite images expressed as integral ratios, Cho/Cr and Lac/Cr, were displayed in different colors. The target was selected in the area of increased Cho/Cr and decreased NAA/Cr ratio. Areas of increased Lac/Cr ratio, if present, were also examined to determine the presence of necrotic areas. The stereotactic target coordinates were correlated with the coordinates from the 1H CSI images.

Results
Stereotactic 1H CSI were possible in all patients without difficulty and definite tissue diagnosis of masses was possible from stereotactic biopsy specimens. Target selection and pathologic results are summarized in table 1. In a patient suspected as having recurrent oligodendroglioma, the area of increased Cho/Cr ratio was selected as the target (Fig. 1 Left). The pathologic report revealed recurrent oligodendroglioma rather than radiation necrosis. In patients suspected as glioblastoma, targets were selected in the area of increased Cho/Cr and decreased NAA/Cr, the pathologic results generally showed features of cellular pleomorphism, atypism, and mitoses. The area showing increased lactate signal proved to have prominent features of tumor necrosis (Fig. 1 Right). The metabolic information from 1H CSI was concordant with the pathologic findings.

Table 1. Patients' Profile. Epileptic Sz. Epileptic Seizure; Memory Imp. Memory Impairment; Radiation Nec. Radiation Necrosis; V/F Defect Visual field Defect

<table>
<thead>
<tr>
<th>No.</th>
<th>Age /Sex</th>
<th>Symptoms &amp; Signs</th>
<th>Tentative Diagnosis</th>
<th>Location of mass</th>
<th>Metabolite Ratio</th>
<th>Pathology</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>39/F</td>
<td>Epileptic Sz.</td>
<td>Radiation Nec.</td>
<td>Left frontal</td>
<td>Cho/Cr (↑)</td>
<td>Oligodendroglioma</td>
</tr>
<tr>
<td>2</td>
<td>58/F</td>
<td>Memory Imp.</td>
<td>Glioblastoma</td>
<td>Spleum</td>
<td>Cho/Cr (↑), Lac/Cr (↑)</td>
<td>Glioblastoma necrosis</td>
</tr>
<tr>
<td>3</td>
<td>60/M</td>
<td>Headache</td>
<td>Glioma</td>
<td>Occipital</td>
<td>Cho/Cr (↑), Lac/Cr (↑)</td>
<td>Glioblastoma necrosis</td>
</tr>
<tr>
<td>4</td>
<td>55/M</td>
<td>V/F Defect</td>
<td>Glioma</td>
<td>Right occipital</td>
<td>Cho/Cr (↑)</td>
<td>Astrocytoma</td>
</tr>
<tr>
<td>5</td>
<td>36/M</td>
<td>Seizure</td>
<td>Glioblastoma</td>
<td>Frontal WH</td>
<td>Cho/Cr (↑)</td>
<td>Astrocytoma</td>
</tr>
</tbody>
</table>

Figure 1. Patient 2. 1H CSI-directed stereotactic biopsy. A 56-year-old female presented memory impairment and headache. The reconstructed color map of the Cho/Cr ratio. The target was selected in the red spot area on the right side of lesion (Left). The reconstructed color map of Lac/Cr ratio over the mass lesion. The area of elevated lactate signal on the right side was selected (Right).

Discussion
MRSAI and PET were introduced as strategies for obtaining more information from metabolic signals during stereotactic biopsy. In the previous report upon proton magnetic resonance spectroscopic imaging and positron emission tomography were used to localize gliomas for biopsy [3]. Go et al. first suggested the usefulness of metabolic information for the selection of biopsy sites. They performed MRI and PET before the application of a stereotactic headframe and the information obtained was used for biopsy targeting. However, there is a difference between Go et al.'s study and our 1H CSI-directed stereotactic biopsy. As we performed 1H CSI with the stereotactic headframe in place, and thus incorporated 1H CSI into stereotactic procedure. Metabolic signals derived from 1H CSI could give us more direct clues for stereotactic target selection during the subsequent conventional stereotactic MR imaging. 1H CSI was feasible with the stereotactic headframe in place. The final pathologic results obtained were concordant with the local metabolic information from 1H CSI. We believe that 1H CSI-directed stereotactic biopsy has the potential to significantly improve the accuracy of stereotactic biopsy targeting.

Reference