3D MR spectroscopy

3D MR spectroscopy techniques allow for improved correlation of metabolite profiles with specific regions of interest in anatomical tumor images, which can be useful in characterizing and treating heterogeneous tumors that appear structurally homogeneous.

Resection based on glioma metabolism information may provide for a more extensive resection and yield better outcomes for glioma patients

In 2014 Kanberoglu et al., developed a clinical workflow and uniquely capable custom software tool to integrate advanced 3-tesla 3D MR spectroscopy into industry standard image-guided neuronavigation systems, especially for use in brain tumor surgery.

3D MR spectroscopy from preoperative scanning on 15 patients with recurrent or newly diagnosed meningiomas were processed and analyzed, and specific voxels were selected based on their chemical contents. 3D neuronavigation overlays were then generated and applied to anatomical image data in the operating room. The proposed 3D methods fully account for scanner calibration and comprise tools that we have now made publicly available.

The new methods were quantitatively validated through a phantom study and applied successfully to mitigate biopsy uncertainty in a clinical study of meningiomas.

The proposed methods improve upon the current state of the art in neuronavigation through the use of detailed 3D Proton magnetic resonance spectroscopic imagingI data. Specifically, 3D MRSI-based overlays provide comprehensive, quantitative visual cues and location information during neurosurgery, enabling a progressive new form of online spectroscopy-guided neuronavigation [1)].

Zhang et al attempt to integrate 3D (1)H-MRS into neuronavigation and assess the feasibility and validity of metabolically based glioma resection.

Choline (Cho)-N acetylaspartate (NAA) index (CNI) maps were calculated and integrated into neuronavigation. The CNI thresholds were quantitatively analyzed and compared with structural MRI studies. Glioma resections were performed under 3D (1)H-MRS guidance. Volumetric analyses were performed for metabolic and structural images from a low-grade glioma (LGG) group and high-grade glioma (HGG) group. Magnetic resonance imaging and neurological assessments were performed immediately after surgery and 1 year after tumor resection.

Fifteen eligible patients with primary cerebral gliomas were included in this study. Three-dimensional (1)H-MRS maps were successfully coregistered with structural images and integrated into navigational system. Volumetric analyses showed that the differences between the metabolic volumes with different CNI thresholds were statistically significant ($p < 0.05$). For the LGG group, the differences between the structural and the metabolic volumes with CNI thresholds of 0.5 and 1.5 were statistically significant ($p = 0.0005$ and 0.0129, respectively). For the HGG group, the differences between the structural and metabolic volumes with CNI thresholds of 0.5 and 1.0 were statistically significant ($p = 0.0027$ and 0.0497, respectively). All patients showed no tumor progression at the 1-year follow-up.

This study integrated 3D MRS maps and intraoperative navigation for glioma margin delineation. Optimum CNI thresholds were applied for both LGGs and HGGs to achieve resection. The results indicated that 3D (1)H-MRS can be integrated with structural imaging to provide better outcomes for glioma resection [2].

1)

Kanberoglu B, Moore NZ, Frakes D, Karam LJ, Debbins JP, Preul MC. Neuronavigation Using Three-Dimensional Proton Magnetic Resonance Spectroscopy Data. Stereotact Funct Neurosurg. 2014 Sep 18;92(5):306-314. [Epub ahead of print] PubMed PMID: 25247480.

2)

Zhang J, Zhuang DX, Yao CJ, Lin CP, Wang TL, Qin ZY, Wu JS. Metabolic approach for tumor delineation in glioma surgery: 3D MR spectroscopy image-guided resection. J Neurosurg. 2016 Jun;124(6):1585-93. doi: 10.3171/2015.6.JNS142651. Epub 2015 Dec 4. PubMed PMID: 26636387.

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