ADC histogram derived RGB color-maps for characterizing low grade glioma subtypes

I. S. Khayal[1,2], T. R. McKnight[1,3], W. Bian[2], S. Cha[3], S. M. Chang[4], and S. J. Nelson[1,2]

[1]UCSF/UCB Joint Graduate Group in Bioengineering, University of California, San Francisco, San Francisco, CA, United States, [2]Surbeck Laboratory of Advanced Imaging, Department of Radiology, University of California, San Francisco, San Francisco, CA, United States, [3]Department of Radiology, University of California, San Francisco, San Francisco, CA, United States, [4]Department of Neurological Surgery, University of California, San Francisco, San Francisco, CA, United States

Introduction: Low grade gliomas are a heterogeneous group of primary brain tumors with variable prognosis and response to therapy. The 3 subtypes of low grade gliomas—oligodendroglioma (OD), astrocytoma (AC), oligoastrocytoma (OA)—are diagnosed based on histopathological analysis of biopsy tissue. This tissue is prone to sampling error and provides information for very limited tissue volume relative to the whole tumor. Prior studies have reported that an Apparent Diffusion Coefficient (ADC) histogram analysis[2] and median ADC analysis[3] may aid in subtyping low-grade gliomas. The goal of this study was to use ADC histograms from patients with astrocytoma and oligodendroglioma to generate RGB color-maps showing astrocytoma-like and oligodendroglioma-like regions. Because biopsies are limited to a very small piece of tissue, dependent on tumor location and safety of accessing the region, this technique allows for the visualization of the biologically different regions within the whole tumor mass, which may aid in image-guided biopsies, assessment of response to therapy, serial assessment or prognosis of clinical outcome.

Methods: A total of 35 newly diagnosed brain tumor glioma patients consisting of 13 AC and 22 OD were scanned on a 1.5T GE Signa Echospeed scanner (GE Healthcare Technologies). The MRI protocol included post-gadolinium (Gd) T1-weighted image, axial T2-weighted images, and either a three directional axial diffusion imaging with (TR/TE= 1000/110ms), voxel size = 1.4×1.4×5mm, b=1000 or a 6 directional axial diffusion imaging with (TR/TE= 1000/108ms), voxel size = 1.7×1.7×3mm, b=1000. Diffusion images were analyzed using in-house software to calculate the ADC. The ADC maps were normalized by normal appearing white matter (NAWM) to generate nADC maps. A semi-automated segmentation method was used to define the T2 hyperintense region (T2All) from the T2 weighted image. Figure 1 shows the histograms of the nADC values within the T2All regions summed for the astrocytomas (blue), the oligodendrogliomas (red) and NAWM of both (green). The color maps were generated as an RGB weighting of red (OD), green (NAWM) and blue (AC). Per voxel, for a specific nADC value, the corresponding histogram value is divided by the maximum height to generate a 0 to 1 scale in red, green and blue, example for nADC=1.5 shown in Figure 1.

Results and Discussion: Figure 2 and 3 show RGB Color Maps of two patients with suspected low grade glioma, from which two regions were biopsied per patient. The patient in figure 2 was histologically classified as an oligodendroglioma, showing mostly an oligodendroglioma-like region (98.6%) with a small patch of astrocytoma-like region (1.4%), based on a cut-off threshold of nADC = 1.8 as shown previously[3]. The patient in figure 3, which was histologically classified as astrocytoma, showing a dominant astrocytoma-like region of 60.3% and an oligodendroglioma-like region of 39.7%. These examples show that within low grade gliomas, there are ADC heterogeneous regions, which could make it importatnt to biopsy within OD and AC weighted regions if both exist. This may also provide clinically important prognostic information as patients continue through therapy.
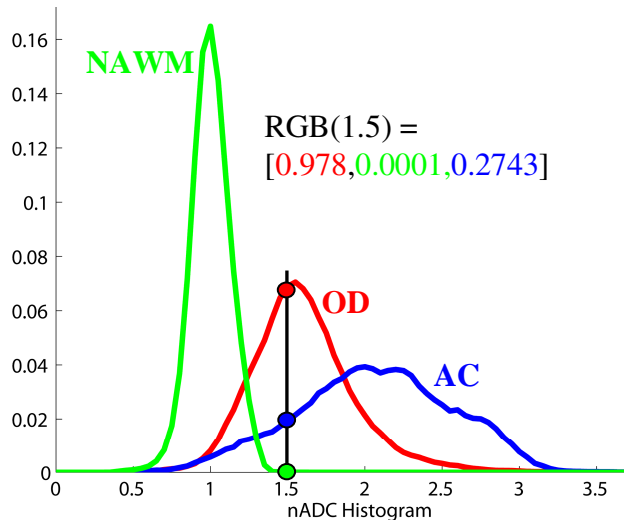

Figure 1. nADC Histograms for NAWM (green), OD (red) and AC (blue), with example RGB matrix for nADC = 1.5.

RGB Color Maps

Figure 2. Example patient with oligodendroglioma showing, based on ADC histogram analysis, an RGB map of OD-like region (reddish-pink) and AC-like region (blue)

Figure 3. Example patient with astrocytoma showing, based on ADC histogram analysis, an RGB map of OD-like region (pink) and AC-like region (blue).

Conclusion: This study utilized ADC histograms from patients with low grade astrocytoma and oligodendroglioma to generate RGB color-maps with astrocytoma and oligodendroglioma weighing. These color-maps provide visualization of the biologically different regions within the whole tumor mass, which may be useful for directing image-guided biopsies in order to obtain tumor tissue from different representative regions of the brain, as well as aiding in assessment of response to therapy, and serial assessment.
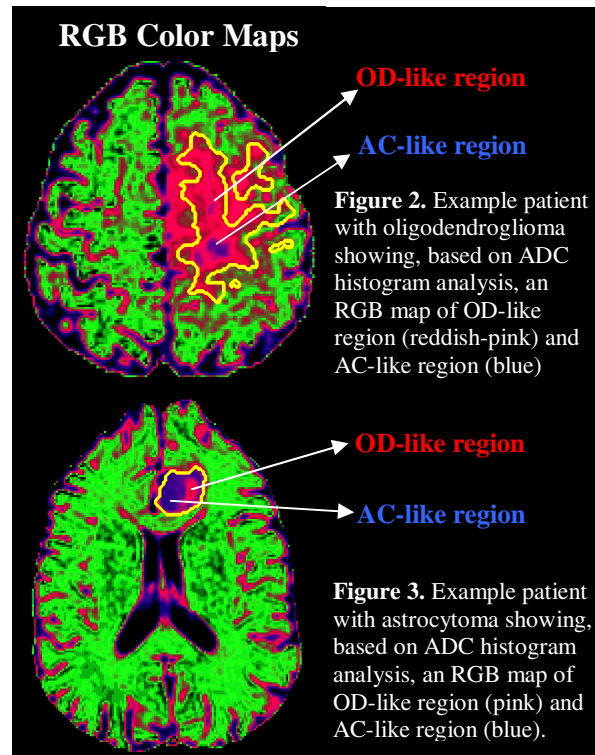
References: [1] Kitange GJ et al. Anticancer Ther. 2001; 1: 595–605. [2] Tozer DJ et al. NMR in Biomedicine. 2007; 2: 49-57. [3] Khayal IS et al. ISMRM proceeding. 2007; 838.