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3DAC PROPELLER: An Overly Under used Powerful MRI Modality

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Introduction

There remains confusion regarding diffusion tensor imaging (DTI) and three dimensional anisotropy contrast (3DAC) imaging [1-6]. While the former represents re-constructed images based on calculated numerical data (eigenvalues) [4-6], the latter is real three dimensional contrast brought about by appropriate optical processing (RGB pictorial mathematics) without estimating eigenvalues [1-3]. This relationship is analogous to T1 (T2) images vs. T1 (T2) weighted images. While the former represents reconstructed images based on numerical data (T1 (T2) values), the latter are images with emphasis on T1 (T2) characteristics without need of estimating actual T1 (T2) values. The gray-scale, gradation based on signal intensity, is the conventional means of providing contrast to digital images. Since these signal intensities possess a one-dimensional (scalar) property, the gray-scale is also one-dimensional. Expansion of contrast from scalar (one-dimensional) to vector (three-dimensional) introduces significantly higher contrast resolution in given images similar to the change of black and white photographs to color. The power of 3DAC in routine clinical magnetic resonance imaging (MRI) studies is illustrated in the following example, parasagittal images showing anatomical details of the middle part of the internal auditory meatus (IAM).

In 3DAC, (x, y, z) coordinates corresponds to (R, G, B) coordinates, therefore, anisotropy of the axial direction is represented by red hue. Since the facial nerve motor division is efferent, its axons show stronger anisotropy compared to sensory afferents (cochlear and vestibular nerves) and, therefore, its chroma in red hue is significantly higher than for the other nerves. (Figure 1) The myelin sheath has virtually no anisotropy and is imaged as a whited out structure as seen for the facial nerve. It is also apparent that the cochlear nerve has a thicker myelin sheath compared to the vestibular nerve. The inferior and superior branches of the vestibular nerve are also clearly identifiable within the oval shaped vestibular nerve. Although cadaver studies of the IAM have been published in the English literature, as shown here, a better, detailed anatomical analysis of nerves within the IAM is easily performed in live subjects using 3DAC [7,8].

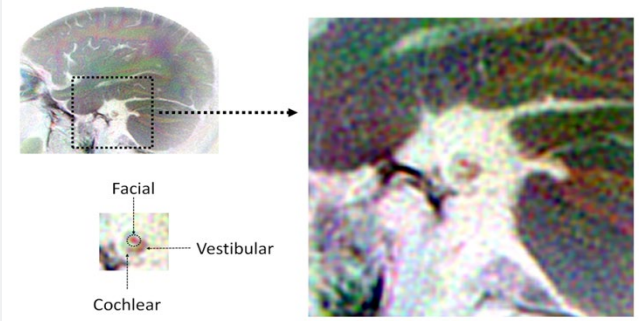

Figure 1

The search for a non-invasive technique that provides higher anatomical resolution is a never-ending quest in clinical medicine. Although digital methods, such as MRI, have accomplished significant advancements reaching microscopic spatial resolution, various obstacles remain in achieving the ultimate goal, namely, a non-invasive imaging technique capable of providing images equivalent to microscopic observation [9-11]. It cannot be overemphasized that, in addition to spatial resolution, contrast resolution plays a major role in determining final anatomical resolution in digital imaging. High quality, qualitative information such as high anatomical resolution images are often of clinical importance far exceeding quantitative measures of similar kind. Furthermore, in order to be truly useful in clinical medicine, such images should be readily obtainable under usual clinical settings where subject related factors including patient comfort take precedence over theoretical feasibility. 3DAC PROPELLER on a 3.0T system as shown here is a method highly suitable for routine clinical analysis and is overly underutilized, primarily due to unavailability of commercial MRI systems. We would like to urge awareness of this MRI modality among medical societies, especially those that are concerned with higher anatomical resolution imaging.

Imaging Methods

A General Electric (Waukesha, WI, USA) Signa 3.0T system was used to perform all imaging studies. Informed consent was obtained from all participants (twenty normal volunteers and eighty volunteers having variety central nervous system diseases) according to the human research guidelines of the Internal Review Board of the University of Niigata. Diffusion weighted PROPELLER images were obtained using the following parameter settings: FOV 22cm x 22cm; matrix 256x256; slice thickness 5mm; intersection gap 2.5mm; Echo Train Length 12; TR 4000msec; TE 78.7msec; NEX 3. The b-value was 1100 sec/mm2 for each axis, with the three combinations of diffusion gradient vectors as follows: (1,0,0), (0,1,0), (0,0,1), where (x, y, z) direction correspond to (right to left, anterior to posterior, superior to inferior) of the brain in supine position. Considering the specific absorption rate, the number of slices was limited to four. The total scanning time necessary to obtain four slice images was approximately 17 minutes. Raw anisotropic diffusion images were transferred to a personal computer (PC) for the following 3DAC image processing.

3DAC MR images were processed using a previously reported method. Three primary colors- red(R), green (G), and blue (B) - were assigned to the gray scale of the three anisotropic diffusion weighted PROPELLER images, x-, y-, and z-axes, respectively. These three primary color images were then combined pixel by pixel to form a single color image in full visible color spectrum. The final images were displayed negatively to obtain a one-to-one correlation between the red, green, and blue colors and the x-, y-, and z-axes, respectively. These images were generated using in-house software written in MATLAB language (Math Works, Natick, MA, USA) on a Windows XP based PC. For details of 3DAC processing and further mathematical formalism, the readers are referred to references 1 and 2.

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References

1. Nakada T, Matsuzawa H, Kwee IL (1994) Magnetic resonance axonography of the rat spinal cord. Neuroreport 5(16): 2053-2056.
2. Nakada T, Matsuzawa H (1995) Three dimensional anisotropy magnetic resonance imaging of the rat nervous system. Neurosci Res 22(4): 389-398.
3. Nakada T, Matsuzawa H, Fujii Y, Takahashi H, Nishizawa M, et al. (2006) Three dimensional anisotropy contrast periodically rotated overlapping parallel lines with enhanced reconstruction (3DAC PROPELLER) on a 3.0T system: A new modality for routine clinical neuroimaging. J Neuroimag 16(3): 206-211.
4. Basser PJ, Mattiello J, Le Bihan D (1994) Estimation of the effective self-diffusion tensor from the NMR spin echo. J Magn Reson 103(3): 247-254.
5. Suzuki Y, Matsuzawa H, Kwee IL, Nakada T (2003) Absolute eigenvalue diffusion tensor analysis for human brain maturation. NMR Biomed 16(5): 257-260.
6. Douek P, Turner R, Pekar J Patronas N, Le Bihan D (1991) MR color mapping of myelin fiber orientations. J Comp Assist Tomogr 15(6): 923-929.
7. Schefter RP, Harner SG (1986) Histologic study of the vestibulocochlear nerve. Ann Otol Rhinol Laryngol 95(2 Pt 1): 146-150.
8. Rubinstein D1, Sandberg EJ, Cajade Law AG (1996) Anatomy of the facial and vestibulocochlear nerves in the internal auditory canal. AJNR Am J Neuroradiol 17(6): 1099-10105.
9. Nakada T, Matsuzawa H, Igarashi H, Fujii Y, Kwee IL (2008) In vivo visualization of senile plaque like pathology in Alzheimer's disease patients by MR microscopy on a 7T system. J Neuroimag 18(2): 125-129.
10. Kwee IL, Matsuzawa H, Nakada K, Fujii Y, Nakada T (2017) Inferior colliculus syndrome: Clinical MR microscopy anatomic analysis on a 7 Tesla system. SAGE Open Medical Case Reports 5: 2050313X17745209.
11. Suzuki K, Yamada K, Nakada K, Suzuki Y, Watanabe M, et al. (2017) MRI characteristics of the glia limitans externa: a 7T Study. Magn Reson Imaging 44: 140-145.

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