Human lifespan age-related changes of the brain proton density by quantitative MRI

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Purpose: Quantitative MRI (qMRI) age-related changes of T1, T2, and diffusion coefficient have been well documented in the scientific literature for normal brain tissues. Proton density (PD) data of the brain across the human lifespan, on the other hand, is not readily available. The purpose of this study was to measure age-related changes in PD of the brain tissues over the full human lifespan.

Materials and Methods: The protocol was approved by the IRB of our institution, and all subjects were consented following NIH HIPAA guidelines. Forty-four subjects (26 males and 18 females, age range 0.5-87 years) were enrolled for this study: 13 volunteers and 31 patients who had either normal-by-MRI findings or small focal parenchymal abnormality less than 6mm in size based on their radiology reports. All subjects were imaged with the mixed-TSE pulse sequence (**Ref.** 1) with a 1.5T MR unit. The whole brain including cerebrospinal fluid (CSF), white (WM), gray matter (GM), and meninges were segmented using a 3-channel dual-clustering algorithm programmed in MathCAD (PTC, Needham, MA). PD maps were normalized to unity relative to the pixel value of CSF in the trigone of the lateral ventricle. PD histograms of the whole brain were generated and resolved into specific tissues (CSF, GM, and WM) by Gaussian functions.

Results: Subjects younger than 2 years of age and older than 75 years of age, had unimodal PD histograms. All other subjects had bimodal histograms with well differentiated WM and GM peaks (**Fig. 1**), very similar to the T1 histogram shapes (**Ref.** 2-4). Peak PD values for GM and WM as a function of age are plotted (**Fig. 2**): PD of GM decreased from 0 to 20 years of age and remained approximately stable during adulthood and senescence periods. PD of WM also decreased in the 0-to-20 years range, stabilized during early adulthood, and increased thereafter.

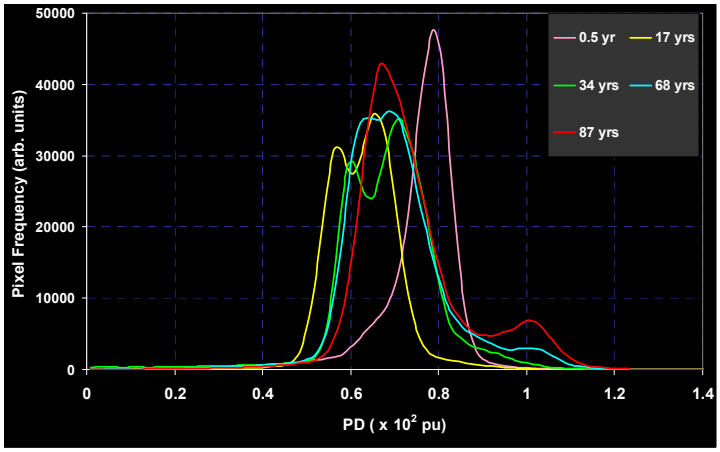

Fig. 1: PD histograms for selected subjects.

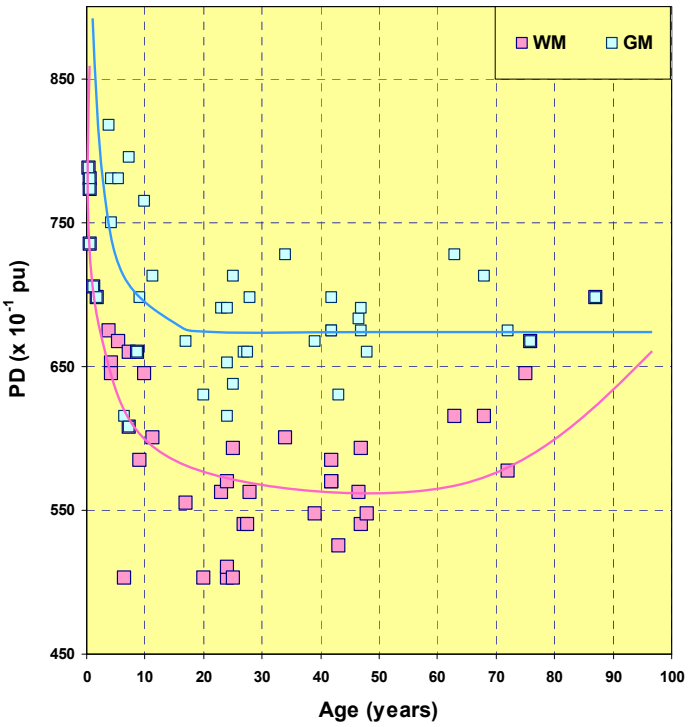

Fig. 2: Age-related peak PD changes for WM and GM of all subjects.

Conclusion: Proton density age-related changes of the normal brain tissues have been studied throughout life. The brain hydration level, as represented in the PD measures for GM and WM, appears to correlate with the known age dependencies of GM and WM by qMRI of T1. To the best of our knowledge, this is the first report of PD age-related effects for the human brain.

References:

1. Suzuki S, Sakai O, Jara H. **Combined volumetric T1, T2, and secular-T2 quantitative MRI of the brain: age-related global changes (preliminary results)**. Magnetic Resonance Imaging 2006; 24(7):877-887.
2. Saito N, Sakai O, Ozonoff A, Jara H. **Relaxo-volumetric multispectral quantitative magnetic resonance imaging of the brain over the human lifespan: global and regional aging patterns.** Magnetic Resonance Imaging 2009; 27(7):895-906.
3. Steen RG, Schroeder J. **Age-related changes in the pediatric brain: proton T1 in healthy children and in children with sickle cell disease.** Magnetic Resonance Imaging 2003; 21:9-15.
4. Cho S, Jones D, Reddick WE, Ogg RJ, Steen RG. **Establishing norms for age-related changes in proton T1 of human brain tissue in vivo.** Magnetic Resonance Imaging 1997;15(10):1133-1143.