Combined multi-spectral quantitative MRI and volumetry of the brain with the mixed-TSE pulse sequence and bisecting dual-clustering segmentation: a technique for studying regional ageing patterns in large populations

N. Saito[1], O. Sakai[1], and H. Jara[1]

[1]Radiology, Boston Medical Center, Boston University School of Medicine, Boston, MA, United States

Introduction: Evolution of the brain during life can be divided in three time periods: a period of maturation characterized by increasing myelination and brain growth, an intermediate adulthood period characterized by relative stability, and an ageing period marked by ventricular enlargement, brain atrophy, and white matter (WM) and gray matter (GM) deterioration. Furthermore, these brain evolution during these three periods' exhibit specific regional trends (**Ref.**1, 2).

Multi-spectral quantitative MR imaging (Q-MRI) and image based volumetry are useful tools for characterizing the biological state of tissues (e.g. hydration level) and overall size of organs respectively. These two complementary tissue/organ characterizations are typically obtained from separate MRI scans, which may differ in imaging positioning and/or spatial resolution.

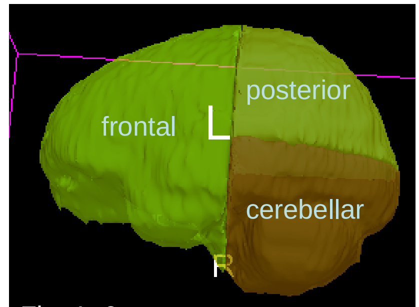

Fig. 1: 6 segments

Purpose: To develop a combined multi-spectral Q-MRI and volumetry technique for assessing segemental brain ageing patterns, generating simultaneously volumetric and tissue hydration measures (specifically, proton density, T1, and T2). Also to test the technique in a large cohort of research subjects (0.5 to 87 years of age) for the purpose of detecting distinct regional brain ageing patterns.

Materials and Methods: 75 subjects (45 males, 30 females, age range 0.5-87 years, average age 39.0 years) were enrolled for this study: 29 volunteers and 46 patients who were referred to MRI for various clinical reasons. All subjects were imaged with the mixed-TSE pulse sequence (**Ref.** 3) by using a 1.5T MR scanner (Philips Medical Systems, Cleveland, OH). The brain was segmented from the whole head data set using a dual-clustering segmentation algorithm. We further divided the whole brain into 6 segments: right and left frontal cerebrum, posterior cerebrum and cerebellum segment. All segmentation algorithms were programmed by MathCAD 2001i (Mathsoft, Cambridge, MA) (**Fig.** 1). Bisecting planes were user defined by selecting three points in more than one slice. First, the right and left hemispheres were divided. Then the frontal and posterior segments were defined with the coronal plane encompassing both sides of the internal auditory canals. Finally, the posterior cerebrum and cerebellum segments were defined with a transverse bisecting plane positioned at the top of the tentorium cerebelli. T1, T2 and PD relaxation time histograms of all segments were generated and modeled with Gaussian functions. Volumes for segmental WM, GM and CSF were measured from the histograms, and then the each percentages of the total segmental volume were plotted as functional of age (**Fig.** 2).

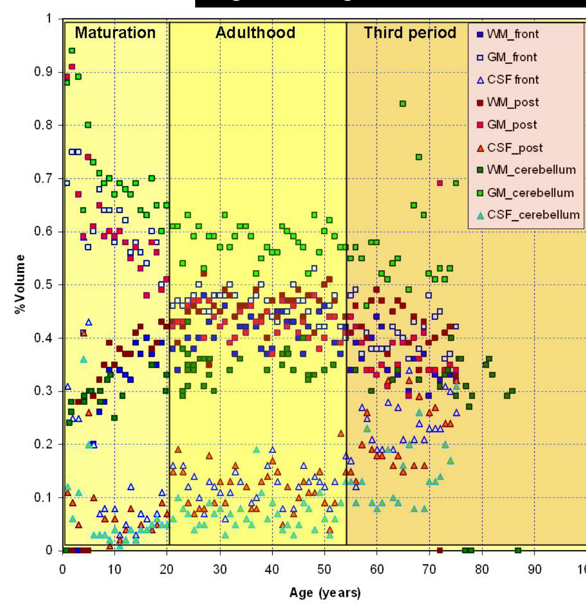

Fig.2: % volume of each segment vs. age (GM, WM and CSF)

Results: For all segments, volumetric changes were most pronounced during maturation (0 to 20 years of age), followed by a stable adulthood period (21 to 55 years of age) leading to atrophy and larger inter-subject variability in the third period of life (56 years and older). Volumetric changes in the cerebellar segments were more gradual than in the posterior and frontal segments. These three periods of brain evolution were also reflected by distinct segmental relaxometric signatures (**Fig.** 3).

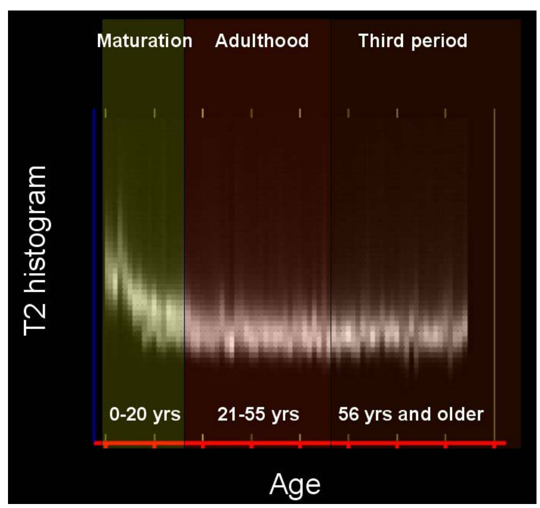

Fig.3: T2 relaxation time vs. age

Conclusion: A combined multi-spectral Q-MRI and volumetry technique for assessing the distinct segmental brain changes through life has been developed and tested with 75 subjects. This method could be applied for studies of various pathologies in the brain at all ages and for establishing relaxometric-volumetric standards.

References:

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