Brain Aging Patterns with ADC Histogram Analysis: a Large Scale and Wide Age Range Retrospective Study (767 subjects, 15 days-93.8 years)

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Introduction: The apparent diffusion coefficient (ADC) age dependency of the human brain have been reported by many groups covering various limited age ranges, and performed by small region-of-interest measurements. Some studies have shown a general trend toward decreasing whole brain ADC's as the brain develops from infancy toward adolescence and remaining relatively constant throughout adulthood with a slight increase during old age (**Ref.** 1-4).

Purpose: To study the age dependence of the whole brain ADC histograms with a large and wide age ranged population. Also to develop mathematical models valid over the full human lifespan describing the aging dependencies of the histogram peaks and widths *vs.* age.

Materials and Methods: This retrospective study was approved by the IRB of our institution and included 767 subjects (370 males, 497 females, age range 15 days -93.8 years, average 44.8 years) who underwent brain MRI for various clinical reasons during 1/1/2007-12/31/2007. All subjects were imaged at 1.5T (Achieva or Intera, Philips Medical Systems, Cleveland, OH) with our institutional clinical protocol that includes the single shot diffusion weighted echo planar imaging (SS-DW-SE-EPI) pulse sequence. Key imaging parameters: 3899/74ms TR/TE, 89 EPI-factor and b=0, 1000smm^{-2}. Scans were DICOM transferred for processing of the ADC using algorithms developed in MathCAD (PTC, Needham, MA). The whole intracranial matter (ICM) including cerebrospinal fluid, white and gray matter was segmented using a two-channel dual-clustering algorithm. ADC histogram of the whole ICM was generated and further modeled with Gaussian functions. ADC peak value and histogram width at 50% of pixel maximum were derived from the histograms and plotted as a function of age.

Results: Clear age-related patterns emerged from the ADC histogram peak value (**Fig.** 1) and histogram width (**Fig.** 2) analyses. Age-related ADC peak value changes were in good agreement with the previously reported results. The following model (**Eq.** 1, x = age in years. **Fig.** 1) was used for demonstrating the ADC peak values *vs.* age.

$$f(x) = \beta_0 + \beta_1 * x + \beta_2 * \exp(-x / \gamma_1) + \beta_3 * \exp(-x / \gamma_2) \quad [\textbf{Eq.}\ 1]$$

Parameter	Estimate	95% CI
β_0	693.4	(674.3, 712.4)
β_1	1.26	(1.01, 1.52)
β_2	208.1	(191.3, 224.9)
β_3	310.3	(285.8, 334.9)
γ_1	14.38	(11.7, 17.1)
γ_2	0.36	(0.30, 0.43)

The following model (**Eq.** 2, x = age in years. **Fig.** 2) was used for demonstrating the ADC histogram widths *vs.* age.

$$f(x) = \beta_0 + \beta_1 * x^2 \quad [\textbf{Eq.}\ 2]$$

Parameter	Estimate	95% CI
β_0	231.0	(229.0, 233.0)
β_1	0.0054	(0.0048, 0.0059)

Both peak ADC values and histogram widths showed increasing inter-subject variance as a function of age.

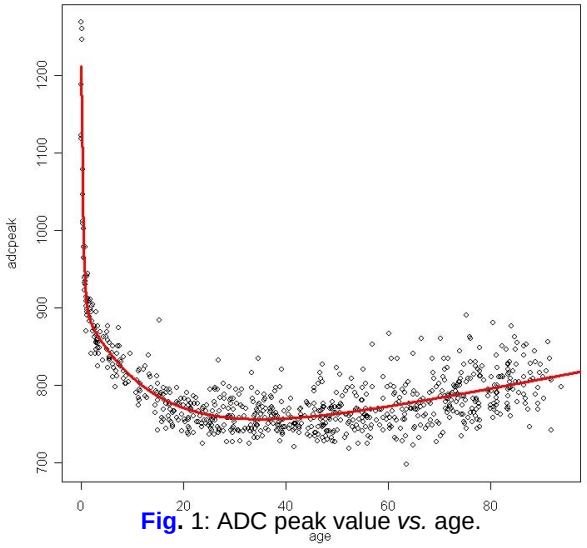

Fig. 1: ADC peak value *vs.* age.

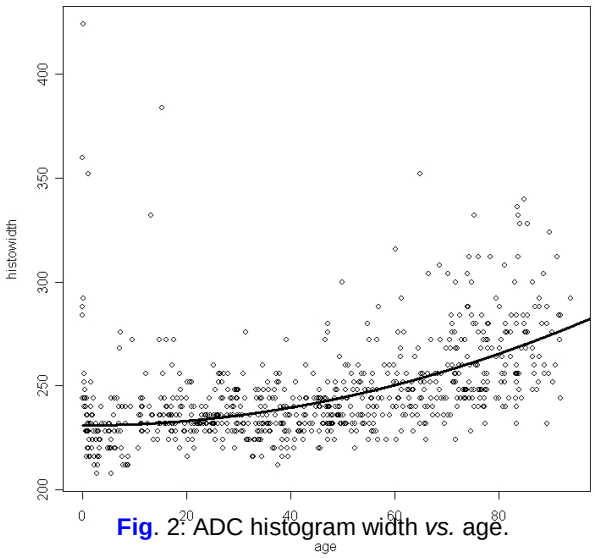

Fig. 2: ADC histogram width *vs.* age.

Conclusion: The mathematical models describing aging patterns of both ADC peak value and histogram width have been developed throughout human life. To the best of our knowledge, this is the largest and widest age range study for whole brain ADC histogram available, as described in the literature.

References:

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