Evaluating g-ratio weighted changes in the corpus callosum as a function of age and sex.

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Abstract:

Recent years have seen a growing interest in relating MRI measurements to the structural-biophysical properties of white matter fibers. The fiber g-ratio, defined as the ratio between the inner and outer radii of the axon myelin sheath, is an important structural property of white matter, affecting signal conduction. Recently proposed modeling methods that use a combination of quantitative-MRI signals, enable a measurement of the fiber g-ratio in vivo. Here we use an MRI-based g-ratio estimation to observe the variance of the g-ratio within the corpus callosum, and evaluate sex and age related differences. To estimate the g-ratio we used a model (Stikov, 2012; Duval et al., 2016) based on two different WM microstructure parameters: the relative amounts of myelin (myelin volume fraction, MVF) and fibers (fiber volume fraction, FVF) in a voxel. We derived the FVF from the fractional anisotropy (FA), and estimated the MVF by using the lipid and macromolecular tissue volume (MTV), calculated from the proton density (Mezer et al., 2013). In comparison to other methods of estimating the MVF, MTV represents a stable parameter with a straightforward route of acquisition. To establish our model, we first compared histological MVF measurements (West et al., 2016) with the MRI derived MTV. We then implemented our model on a large database of 92 subjects (44 males), aged 7 to 81, in order to evaluate age and sex related changes within the corpus callosum. Our results show that the MTV provides a good estimation of MVF for calculating g-ratio, and produced values from the corpus callosum that correspond to those found in animals ex vivo and are close to the theoretical optimum, as well as to published in vivo data. Our results demonstrate that the MTV derived g-ratio provides a simple and reliable in vivo g-ratio-weighted (GR*) measurement in humans. In agreement with theoretical predictions, and unlike other tissue parameters measured with MRI, the g-ratio estimations were found to be relatively stable with age, and we found no support for a significant sexual dimorphism with age.
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