# Retrospective Motion Correction of MPnRAGE Studies in Children

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**Target Audience:** Researchers and clinicians who are interested in motion correction of structural images for pediatric neuroimaging studies.

**Purpose:** Brain imaging studies in young or intellectually impaired children while awake can be extremely challenging because head motion will lead to significant image blurring, ghosting and other artifacts. Thus, children are often sedated for clinical MRI studies, which increases the cost of the study and may cause significant adverse side effects. An alternative strategy is to image children during natural sleep; however, this is a time-consuming, costly and not 100% effective strategy. Even small, naturally occurring motions during sleep can cause significant image artifacts using conventional 3D T1-weighted imaging with MP-RAGE. Recently, 3D MPnRAGE was developed as a variation of 3D MP-RAGE using radial k-space sampling [1]. A sliding window reconstruction takes advantage of the radial oversampling of the central region of k-space, which may be used to efficiently generate hundreds of images with different inversion recovery contrasts and quantitative T1 maps. For example, it is possible to obtain high-quality whole-brain MPnRAGE data with 1mm isotropic resolution, roughly 300 inversion recovery contrasts, and a quantitative T1 map with calibrations for B1 errors in an 8.5 minute scan without parallel imaging. Radial k-space sampling is also inherently less sensitive to motion as the artifacts manifest more as blurring than ghosting [2]. Radial k-space sampling also enables self navigation [3], which may be used to retrospectively correct MPnRAGE images [4]. This study applies for the first time retrospective motion correction to MPnRAGE studies of children with autism and fragile X syndrome as well as typically developing controls. In addition, the study also originally demonstrates that this method also effectively corrects for slow and continuous head movements (as opposed to discrete head motion events [3,4]) and that motion may be corrected on the time frame of the interval between MPnRAGE inversion pulses (~ every 2 s).

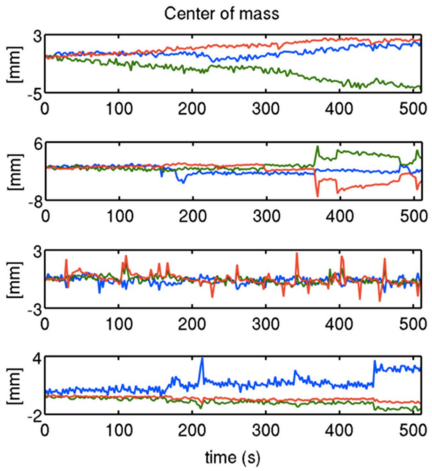

**Fig 1**. XYZ COM plots (in RGB) versus time for all volunteers A-D (top-bottom) – see Fig 2.

**Methods:** *MRI Acquisition:* MPnRAGE studies were obtained in twenty-five children (ages 8-19 years old) from two pediatric neuroimaging studies of autism and fragile X syndrome. The studies were performed with informed consent and parental assent in compliance with the Institutional Review Board. Imaging was performed at 3T using a 32-channel receive-only head coil. The MPnRAGE protocol parameters include: FOV = 256 mm x 256 mm, non-selective excitation (whole head), isotropic resolution = 1.0 mm, 302 TRs (4.89 ms) starting 20 ms after each inversion, 2.25s between inversion, TE = 1.8 ms. Three additional orthogonal radial views were acquired at the end of the inversion recovery readout to estimate the center of mass (COM) [3,4]. The total scan was 9.0 minutes. Moderate MPnRAGE image blurring from motion was observed in four cases (2 FXS, 1 Autism, 1 typically developing) on the T1-weighted MPnRAGE images and are the focus of the study here. *Motion Correction:* Plots of the COM were generated for each coil, which revealed unique motion patterns for each participant. In two of the participants, the data were partitioned into motion consistent intervals [3] and in the other two participants, motion was determined to be more continuous so the correction was performed for data from each inversion pulse (every 2.25 seconds). In all cases, low resolution (8 mm) self-navigator images were reconstructed for each motion partition and the partitions were co-registered using FSL FLIRT rigid body registration. The spatial transformations were applied to the imaging data and then combined to generate motion corrected images with high spatial resolution.

**Results:** For the 4 cases, Fig 1 illustrates COM motion detection and Fig 2 illustrates reconstructed T1-weighted MPnRAGE images both with and without motion correction.

**Discussion:** Visual inspection of the MPnRAGE images revealed that the motion corrected images were less blurred and structural features were more clearly defined. Retrospective motion correction appeared to work well for both discrete and more continuous motion effects. This is only an initial investigation and more studies are certainly needed to evaluate this technology for broader applications. To date, we have not observed any cases where the correction has not improved image quality, though correction of frequent severe motion may not be possible. To date, the correction has only been evaluated for the MPnRAGE T1-weighted images. Future studies will evaluate the correction for other MPnRAGE contrasts and quantitative T1 maps.

**Conclusion:** MPnRAGE with retrospective motion correction appears to be a promising method for obtaining robust high quality T1w structural images in challenging-to-image pediatric populations and will also be applicable to a broad range of general neuroimaging applications.

**References:** **[1]** Kecskemeti SR, et al. 2013 ISMRM #0452 **[2]** Glover, G.H. et al, Magn Reson Med, 1992, 28(2); p.275-89 **[3]** Anderson A.G. et al, Magn Reson Med, 2013. 69(4): p.1094-103. **[4]** Kecskemeti SR, et al. 2014 ISMRM #4343

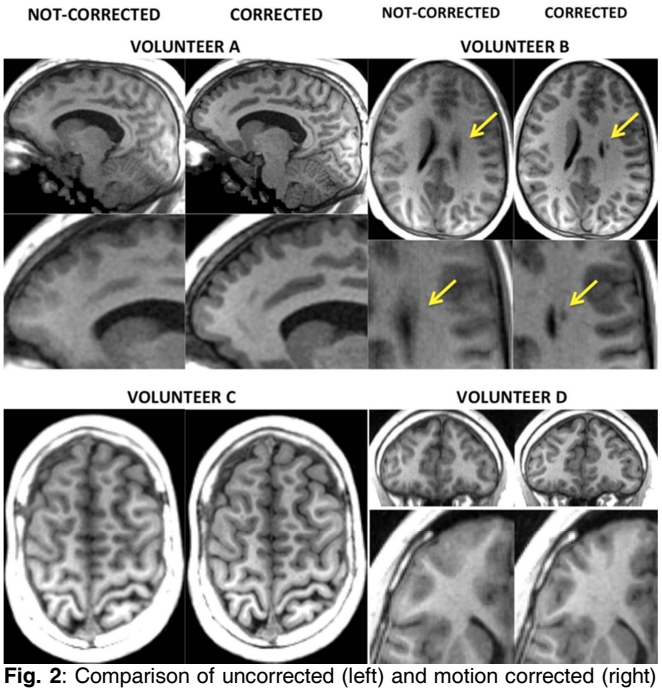

**Fig. 2**: Comparison of uncorrected (left) and motion corrected (right) 3D MPnRAGE T1w image pairs for four awake pediatric studies. In all cases motion corrected images better delineated WM/GM boundaries. In one case a lesion was detected (yellow arrow) that was not seen without the correction.