Which to choose for volumetry: MPRAGE or SPACE?

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Introduction: From a clinical viewpoint, T1-weighted images is used to evaluate lesion signal at pre- & post-contrast enhancement. Especially in contrast-enhanced cases, T1-weighted 3D variable flip angle (VFA) fast spin-echo (FSE) sequence called, SPACE [1] is recognized as superior to 3D MPRAGE [2] and gradually accepted in clinical practice [3]. On the other hand, MPRAGE is one of the most widely used sequences for brain volumetry. It is a magnetization-prepared gradient echo (GE) imaging with very short TR and TE. T1-weighted 3D SPACE is a derivative of FSE with low SAR and long echo train length, which is suitable for a volume scan. It has high T1 contrast by using optimized flip angle pattern and flipping down residual transverse magnetization at the end of each data acquisition, so that signals form long T2 components are partially cancelled to increase T1 contrast. The FSE sequence is known for its robustness for local field inhomogeneity at such areas as skull base. Moreover, radial *k*-space trajectory can be adopted in SPACE, which enables shorter TE for less dephasing and makes the imaging more robust to motion artifact. With a higher magnetic field strength and multiple array coil system, these scans can be conducted around 5 minutes, which means that these volumetric methods is available in daily clinical practice. Their similarity and difference for volumetry, however, have not been much investigated. Therefore, we conducted a comparative study of MPRAGE and SPACE to investigate reproducibility of each sequence and any difference in segmented volumes with focus on gray matter (GM) within this article.

Methods: Both 3D-MPRAGE and 3D-SPACE images were acquired in 10 healthy subjects (9 males, 1 female, age range: 22-30 years, average 25 years old) using a 3T scanner (MAGNETOM Skyra, Siemens Healthcare, Erlangen, Germany) with a 16-channel head coil, after getting written informed consent under institutional review board approval. The resolution were the same: field-of-view 230mm, matrix 256×256, in-plane resolution 0.9×0.9mm, slice thickness 0.9mm, number of slices 192. Other parameters of MPRAGE were: TR 1900ms, TE 2.13ms, TI 900ms, FA 9, parallel imaging (PI) factor 2, averaging 1 and acquisition time (TA) 4:26. Those of SPACE were: TR 530ms, TE 7.8ms, PI factor 2×2, averaging 1.5 and TA 5:19. These measurements were repeated twice. The subjects got off the scanner table between two sessions. Both MPRAGE and SPACE image volume pairs were coregistered, spatially normalized, segmented for GM and smoothed with Gaussian kernel of isotropic 6mm full-width half-maximum by using SPM8. Difference in GM volume (represented from 0 to 1) was calculated for the repeated measurement pairs, and compared between MPRAGE and SPACE for each voxel by using paired *t*-test. A P value < 0.05 was considered significant after correction for false discovery rate [4]. Averaged difference of all subjects in GM volume for the whole brain was also calculated and presented.

Results: MPRAGE had no area that had significantly higher GM volume difference compared with that of SPACE. However, SPACE had many regions with significantly higher differences compared with MPRAGE. Such areas are wide-spread and not limited to skull base (Figure 1). Average differences in GM volume for each sequences are presented in Figure 2. MPRAGE showed very low variances, except for brain stem and probable venous sinuses, which had slightly higher differences. In SPACE, high differences in probability of GM was observed, especially at the brain stem, cerebellum and occipital lobe. Dark red areas indicate more than 5% GM volume difference between two repeated measurements.

Discussion: SPACE had surprisingly high variance in reproducibility of GM volume measurement. There are some possible reasons for this: 1) less GM-WM contrast compared to MPRAGE that uses inversion recovery to increase contrast between them, 2) SPACE uses very large echo train length and residual T2 blurring effect may obscure GM-WM boundary, even after optimization of VFA, and 3) possible lower signal-to-noise ratio due to 2D-PI used in SPACE to make scan time equivalent to MPRAGE. These factors probably contributed to unstable segmentation results. Moreover, cortex is thinner than other regions at the cerebellum and occipital lobe [5], and the brain stem is complicated with interposed nucleus within many tracts, which probably made segmentation much less robust. On the other hand in MPRAGE, large sinuses and vessels have similar signal intensity to GM, and they may affect estimation of GM probability at their vicinity (see figure 2). Caution has to be paid to this issue. In conclusion, SPACE mat not be a substitute of MPRAGE for the purpose of brain volumetry.

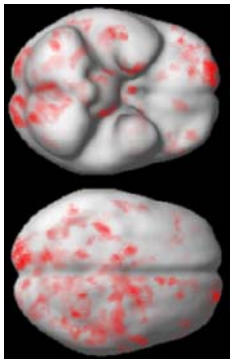

Fig 1. Areas with higher variance in SPACE vs. MPRAGE.

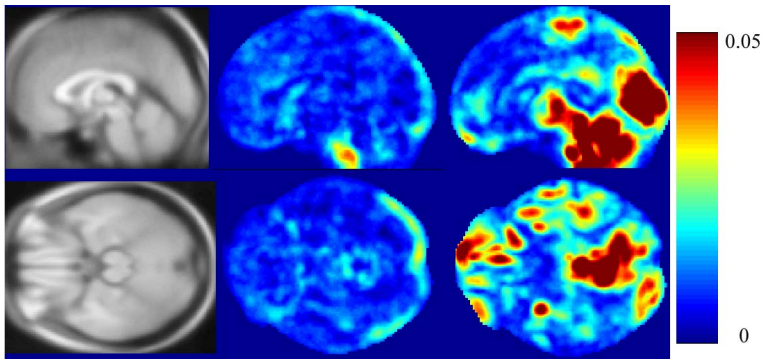

Fig 2. Regional differences in GM volume. Left: anatomical template, Middle: MPRAGE, Right: SPACE

Refereces: [1] Park et al. MRM 58:982-992 (2007), [2] Mugler et al. JMRI 1:561-67 (1991), [3] Kato et al., AJNR 30:923 (2009), [4] Genovese et al., NeuroImage 15:870-8 (2002), [5] O'Donnell et al., NeuroImage 24:948 (2005).