Application of single-slab 3D-FLAIR, 3D-DIR and 3D-T2, compared to 2D dual-echo T2, in multiple sclerosis patients

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Introduction

In clinical multiple sclerosis (MS) trials a 2D dual-echo T2 weighted spin-echo (T2SE) is generally employed to identify active T2 lesions and to measure lesion load. For a reliable comparison of longitudinal datasets a good repositioning is mandatory but often difficult to achieve (1). Registration (and subsequent subtraction) can partially solve these problems but the relatively thick slices (≥3mm) of the 2D-T2SE induces blurring. Image analysis might benefit from 3D imaging modalities that allow the acquisition of thinner slices with near isotropic voxel sizes. A single-slab 3D method for several contrasts (FLAIR, T2) has been developed (2). A DIR sequence was added since an earlier study (3) using a multi-slab DIR demonstrated increased detection of intracortical lesions. The goal of the current study was to perform a cross-sectional analysis, comparing the single-slab 3D-FLAIR, 3D-DIR and 3D-T2 to the routinely used 2D-T2SE.

Patients&Methods

Sixteen patients (nine females) with clinically definite MS were randomly selected from a clinical database. Imaging was performed on a 1.5T whole body scanner (Siemens Sonata, Erlangen, Germany), using a standard circularly polarized head coil. Per subject 4 sequences were acquired in random order, 2D-T2SE (TR/TE 2690/45/90), 3D-T2 (TR/TE 4300/349), 3D-FLAIR (TR/TE/TI 6500/349/2200) and 3D-DIR (TR/TE/TI1/TI2 6500/349/2350/350) (Figure 1).
The 3D images with near isotropic voxel sizes of 1.2x 1.2x 1.3 mm^3 were co-registered to the 2D images (1x1 mm^2 in-plane, 3 mm slice thickness), using FLIRT/FSL, with normalized mutual information and sinc interpolation with a kernel size of 7 voxels FWHM and 1.25mm isotropic voxels. The registered images were analyzed in random order by a single observer and lesions were characterized according to the anatomical localizations shown in Table 1.

Results

The total number of lesions identified on the single-slab 3D images were 945 (DIR), 1031 (FLAIR) and 825 (T2), compared to 959 for the 2D sequence. Mean lesion counts per topographic region (Table 1) show an increased detection of cortical and mixed WM-GM lesions using the 3D-DIR images. The 3D-T2 showed an overall decreased identification of lesions and was particularly weak in identifying cortical and mixed WM-GM lesions. The highest numbers of lesions were identified on the 3D-FLAIR images, especially in the deep white matter.

Discussion

The single-slab 3D FLAIR and DIR allow for a better differentiation of MS lesions according to location; 3D-DIR was most sensitive for cortical and mixed WM-GM lesions, whereas 3D-FLAIR was most sensitive for deep WM lesions. This might be explained by the high contrast between white matter and gray matter. The lower sensitivity of the 3D-T2 sequence is probably due to the relatively low contrast between lesions and CSF. Future studies have to demonstrate the distinct advantages of the single-slab 3D datasets using registration and subtraction.

Table 1: Mean number of lesions by location and sequence

	3D-DIR	3D-FLAIR	3D-T2	T2SE
Intracortical	3.8 ± 3.1	1.0 ± 1.8	0.0 ± 0.0	0.6 ± 1.1
Mixed WM-GM	4.0 ± 5.0	2.5 ± 3.2	0.1 ± 0.3	0.8 ± 1.7
Juxtacortical	6.4 ± 7.7	4.6 ± 4.8	4.0 ± 4.6	12.9 ± 15.7
Deep Gray Matter (GM)	0.9 ± 1.6	1.9 ± 2.7	2.2 ± 2.8	1.7 ± 2.1
Periventricular WM	21.1 ± 10.0	20.8 ± 8.3	16.8 ± 9.6	16.3 ± 9.0
Deep White Matter (WM)	19.7 ± 12.9	30.1 ± 27.8	24.6 ± 21.5	24.9 ± 22.5
Infratentorial	3.3 ± 3.0	3.6 ± 4.7	3.9 ± 6.3	2.8 ± 4.6

Table 1. Note the redistribution of juxtacortical, mixed WM-GM and intracortical lesions in the 2D-T2SE, 3D-FLAIR and 3D-DIR

References

1. Goodkin et al. Arch Neurol 1993; 50:569-571
2. Mugler et al. Radiology 2000; 216:891-899
3. Geurts et al. Radiology 2005; 236:254-260

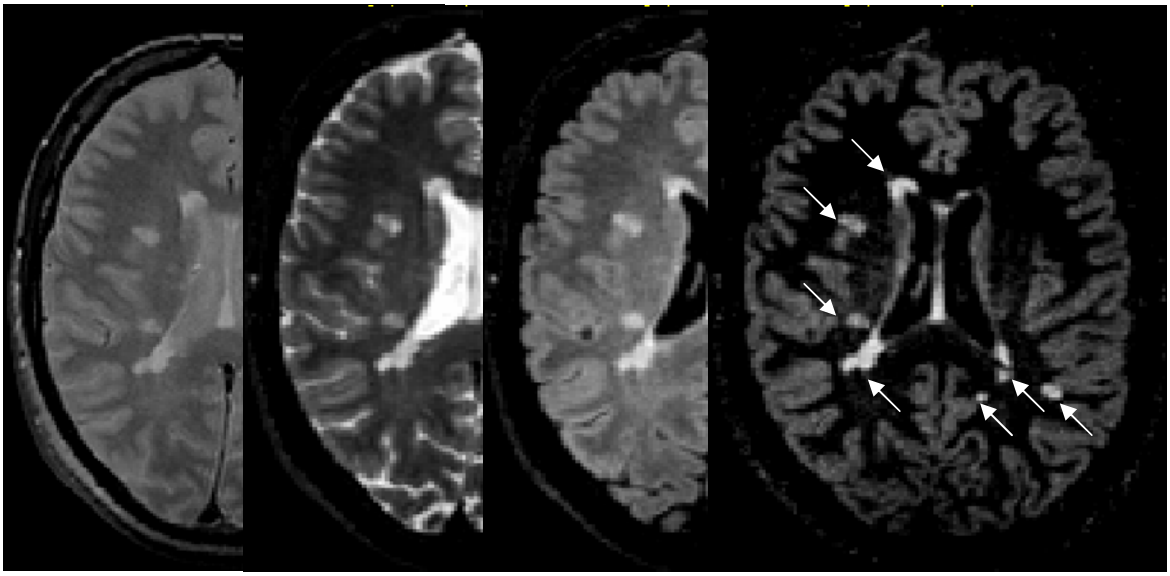

Figure 1. From left to right the 2D-T2SE, 3D-T2, 3D-FLAIR and 3D-DIR images, as analyzed in this study. Note the high contrast between lesions and CSF in the FLAIR image, and the high contrast between lesions and both CSF and WM in the DIR images. Images show various periventricular and deep WM lesions.