Optimizaion of Imaging Parameters of 3D-FSE-XETA FLAIR for Detection of Multiple Sclerosis (MS) Lesions on a 3T scanner

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INTRODUCTION:

3D-FSE-XETA (eXtended Echo Train Acquisition) is an implementation of a single-slab imaging sequence, along the lines first proposed by Mugler et al. [1,2]. The sequence applies modulated flip angle refocusing RF pulses that enable very long echo trains to generate T2-weighted images. With applying inversion pulses to null the CSF signal, the 3D-FSE-XETA FLAIR sequence can be used to acquire high-resolution T2-weighted images for detecting brain lesions of different diseases, such as multiple sclerosis. We hypothesized that the detection of small MS lesions, especially subcortical/cortical lesions (SCL) can be improved by optimizing echo time and voxel size on 3D-FSE-XETA-FLAIR, while maintaining SNR at a level acceptable for anatomical delineation, taking advantage of the greater SNR at 3T. In this study we verified imaging parameters, such as TE, voxel size, etc., for the tissue/lesion contrast and lesion detection while SNR, spatial resolution and imaging time are maintained at an acceptable level, based on the data obtained from a phantom study (presented separately), in MS patients and healthy volunteers.

METHOLOGY:

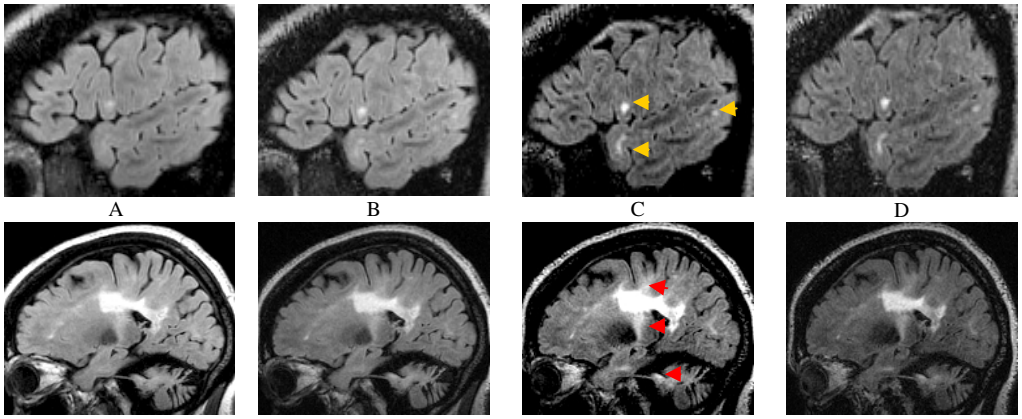
Subjects: 5 MS patients (aged 33-58 years) and 5 normal healthy volunteers (aged 28-49 years) were recruited into the study.

MRI acquisition: the 3D-FSE-XETA (eXtended Echo Train Acquisition) FLAIR sequence [2] was tested on a 3T MR scanner (GE Signa) with the following parameters: automatically calculated TI for nulling CSF signal; TR=6200 msec; TEs, ranging from 130 (GE prototype), 155, 200, 220 msec for improving T2 contrast between lesions and normal brain tissues. Slice thickness of 1.2, 1.6 and 2.0 mm was also tested to gain SNR while increasing TE. The scan time for 136 slices was 6'34" which is remarkably short for a high-resolution full FOV FLAIR sequence, enabling subjects to better hold their position and minimize motion artifacts.

Clinical Reading: normal anatomical structure (Graded as: excellent, good, fail, poor and unacceptable), lesion detection (blinded reading by 2 well-trained radiologists), lesion conspicuity, CNR and SNR, and imaging artifacts were compared among images with different TEs. The T2 weighted spin echo images and proton density images were used as reference.

RESULTS:

Consistent with the phantom test (presented separately), our data showed that best results were obtained using TE=200 msec with isotropic 3D acquisition with 1.2mm^3 nominal voxel size, yielding excellent CNR and SNS for detecting SCL (Figures A-D). The SNRs gradually decrease with the increase of TEs from 110% to 96%, while contrast between the gray to white matter increased with 200msec as the maximum. Delineation of normal anatomy was graded almost the same for all images with different TEs. MS lesions, however displayed a marked increase in contrast and conspicuity with longer TE. More MS lesions were detected with a TE of 200 and 220 msec, but the SNR was unsatisfactory with TE of 220msec. Several imaging artifacts become prominent when TE exceeded 200 msec, mainly the nerve tract (probably corticospinal tract) that starts from the white matter around central gyrus downwards to the internal capsule, midbrain and pons, as well as hyperintensity in the superior cerebellar peduncle. These hyperintense normal anatomical structures were observed in both MS patients (Figures E to H) and normal healthy volunteers, and they mimic demyelinating lesions during interpretation. However, none of them were misdiagnosed as MS lesions as the reviewers identified them as normal structures by tracking their path.



Figures A to D demonstrate the effect of TEs of 130 (A), 150 (B), 200 (C) and 220 (E) msec in an MS patient. More lesions can be confidently identified with a TE of 200 and 220 msec (C and D). Figures E to H reveal the effect of TEs of 130 (E), 150 (F), 200 (G) and 220 (H) msec, respectively, on increasing the contrast of a normal anatomical structure (arrows) in a MS patient. Note the hyperintense neural tract, starting from subcortical white matter around the central gyrus, extending downward to the internal capsule. This hyperintensity becomes prominent with a TE above 200 msec. It is undesirable as it mimics MS lesions.

DISCUSISON:

3D-FSE-XETA FLAIR is a promising sequence for MS imaging on 3T scanners. The MS lesions can be identified with higher confidence when the parameters of TE and voxel size are optimized to increase lesion contrast and conspicuity. This technology is also of importance to facilitate automatic segmentation for lesion volume calculation. However, care must be taken to differentiate normal structures which were displayed with high intensity when TE is elongated.

References: [1] Mugler JP et al , Radiology. 2000 Sep;216(3):891-9. [2] Busse RF et al., MRM,55, p1030 (2006)