Morphometric MRI Analysis Based on High Resolution 3D Imaging at 7 Tesla Highlightes Focal Cortical Dysplasia in Epilepsy

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INTRODUCTION

Very high field strength of 7T has mainly been used for methodological or basic scientific studies. So far, very few studies have evaluated the clinical gain of the increased field strength. High field data show an increased signal to noise ratio but they may be compromised by stronger inhomogeneity, varying contrast, or increased susceptibility losses. In many epilepsy patients, the localization of the underlying epileptogenic lesion is difficult if not impossible with current imaging methods, and invasive EEG recordings are frequently required to delineate the epileptogenic zone. Recently, morphometric MRI analysis based on high resolution anatomical MRI has been proposed as a promising tool for the detection of small focal cortical dysplasia (FCD), a frequent cause of pharmacoresistent focal epilepsy [1]. The purpose of this feasibility study was to test whether whole brain anatomical imaging at 7 Tesla can be used as a basis for morphometric MRI analysis. The potential benefit of the increased spatial resolution was evaluated in a test patient with an already known but subtle epileptogenic lesion.

MATERIALS AND METHODS

The test patient suffers from focal epilepsy due to a small FCD in the left frontal paracentral region. Informed consent was given according to local IRB approval. The MRI was acquired on a 7T system (Siemens, Erlangen, Germany) using a 24 channel head array coil. For anatomic imaging 3D-MPRAGE (TE, TR, flip, 0.8mm isotropic resolution) and T2-weighted hyper-TSE (TE, TR, 30 slices, 0.4*0.4*2mm) was performed. Correction of the signal and contrast inhomogeneities caused by spatial B1-variation was done by division of the MPRAGE data by a 3D-gradient echo (GE) data set (identical parameters, no inversion, minimal TR) [2]. Based on the corrected MPRAGE data a fully automated morphometric analysis technique including algorithms of SPM5 was applied to calculate a feature map highlighting brain areas with blurring of the gray-white matter junction [1]. In order to assess the improvement due to increased spatial resolution of the 7T MRI the data set was processed not only with the standard 1 mm voxel resolution but also with an interpolated isotropic resolution of 0.5 mm. The algorithm was adopted by adjustment of the filter kernel size according to the increased spatial resolution of the data.

RESULTS

The correction of the MPRAGE data through division by the GE data resulted in very homogeneous and high contrast anatomical data (Fig. 1). Morphometric analysis based on the corrected MPRAGE data successfully detected and highlighted the FCD. In contrast, the feature map from uncorrected data showed false positive results in unaffected brain regions mainly due to local variations in gray-white matter contrast (Fig. 2). A reduction of the voxel volume from $1mm^3$ to $0.5mm^3$ resulted in an obvious improvement in the delineation of the gray-white matter interface in the feature map and therefore may provide higher conspicuity of subtle cortical malformations (Fig. 3).

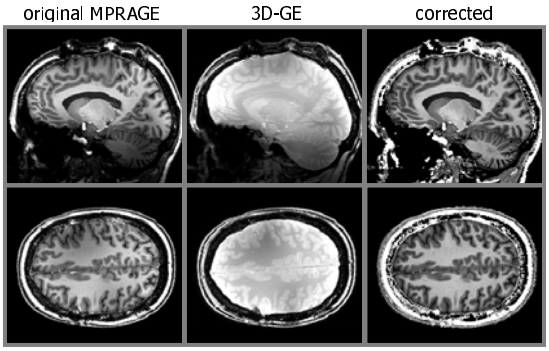

Fig. 1: Original and corrected MPRAGE show high contrast and homogeneity in the corrected data.

DISCUSSION

High resolution 3D anatomical T1 imaging with high contrast and good homogeneity in signal and contrast at 7T is possible at the cost of one additional 3D GE scan increasing the total measurement time. This scan, however, yields opposing contrast and thus not only corrects but also improves the overall contrast to noise in the data. Fully automatic morphometric MRI analysis highlighting areas of blurred gray-white matter junction is possible on the basis of these corrected data. The higher resolution afforded by the use of ultra high field strength can be translated into feature maps of higher conspicuity. Further studies of patients with cryptogenic epilepsy will evaluate whether a clinical benefit can be realized and if anatomical abnormalities can be detected in more patients compared to lower field strength.

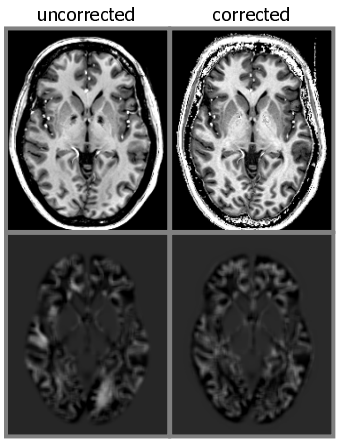

Fig. 2: Feature maps calculated from original uncorrected and corrected data. Without correction bright areas suggestive of dysplasia are detected in unaffected brain regions.

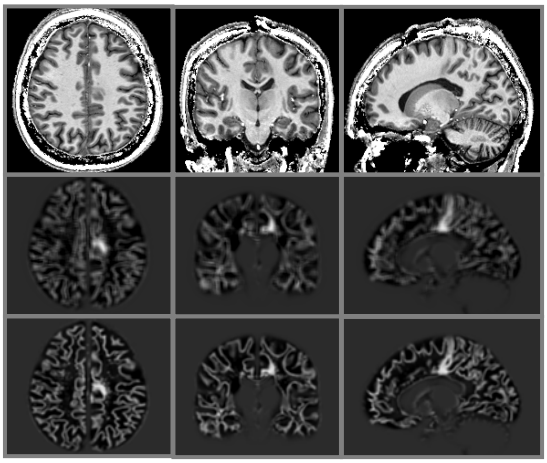

Fig. 3: The T1 image and the feature maps highlighting blurred gray-white matter junctions at standard (1mm, middle row) and increased (0.5mm, bottom) resolution.

REFERENCES

[1] Huppertz et al.: Enhanced visualization of blurred gray-white matter junctions in FCD by voxel-based 3-D MRI analysis. Epilepsy Res, 2005

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