Effects of Field Strength on Serial MR Neuroimaging

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Introduction

Serial magnetic resonance (MR) studies that seek to identify subtle changes over time typically involve registration and subtraction of the images from different time-points, followed by analysis of the difference images [1,2,3]. For multicentre studies it is desirable to transfer serial MR imaging research protocols from one scanner to another, potentially using different field strengths and RF coil technologies. We compare serial MR images from 10 volunteers and their resulting subtraction images acquired with similar protocols at both 1.5T and 3T.

Method

Acquisition: Baseline and repeat scans were acquired from each of 10 volunteers on both a 1.5T and a 3T Philips Intera scanner (Philips Medical Systems, Best, The Netherlands). 5 volunteers were imaged with an 8-element array coil and 5 with a birdcage coil (transmit-receive at 3T, receive only at 1.5T). Array coil scans were corrected for RF inhomogeneity using a reference scan (SENSE factor 1). The MR sequence was matched as closely as possible between scanners. A 3D gradient echo sequence (MPRAGE, transverse slab, flip angle of 8°, 1.2mm cubic voxels, readout AP) had the inversion time (TI) optimised, within the constraints of the acquisition, to give similar contrast (TI = 900 ms at 1.5T, TI = 1250 ms at 3T). The shortest possible TR was chosen that accommodated the echoes with the desired inversion time occurring in the middle of the echo train.

Image analysis: Baseline and repeat scans acquired at the same field strength were rigidly registered by optimisation of normalised mutual information using vtkCISG software (www.image-registration.com). Difference images were produced by subtracting repeat scans, transformed using sinc interpolation, from the baseline scans. These were re-formatted in the coronal plane and windowed to +/- 35% of the cortical grey matter intensity. The slice with the most severe flow artefact was visually identified in each of these difference images. Regions of interest (ROI) were placed in this slice over the area with the most severe artefact and over an area appearing free of artefact. Artefact was quantified as the ratio of standard deviations across the intensity difference values between the two ROI's. Artefact ratios were compared for each subject at both field strengths. The 1.5T and 3T images (Baseline scans alongside their related difference images) from each subject were randomised and a radiologist ranked the comparative artefact present in the images of the two field strengths on a 5-point scale.

Results

Comparison of 1.5T and 3T images showed the expected differences in contrast, signal homogeneity and SNR (which is a factor of 2 higher at 3T) (Figure 1). Inspection of the difference images showed more pronounced flow artefacts at 3T and more noise at 1.5T. Table 1 shows that the artefact level at 3T is larger than at 1.5T (more than twice as large on average). This difference was found to be significant (P<0.01, paired Student's t-Test). In the visual assessment study, the radiologist ranked the images at 3T as having more pronounced flow artefacts for 8 of the volunteers with 4 rated much more pronounced. For 1 volunteer the artefact level was indistinguishable and for 1 it was rated slightly more noticeable at 1.5T. A Wilcoxon matched pairs signed-rank test showed that this difference was significant at the 5% level (P<0.05).

Ratio of SDs	Birdcage results						Array coil results						Collated
of ROIs at:	Vol1	Vol2	Vol3	Vol4	Vol5	Average	Vol6	Vol7	Vol8	Vol9	Vol10	Average	Average
1.5T	1.495	1.636	1.252	1.859	1.347	1.518	2.180	2.209	1.835	2.124	1.919	2.053	1.785
3T	3.124	3.910	3.216	3.797	2.792	3.368	5.002	3.755	4.487	6.263	4.826	4.886	4.117

Table 1 – Comparison of artefact level at different field strengths

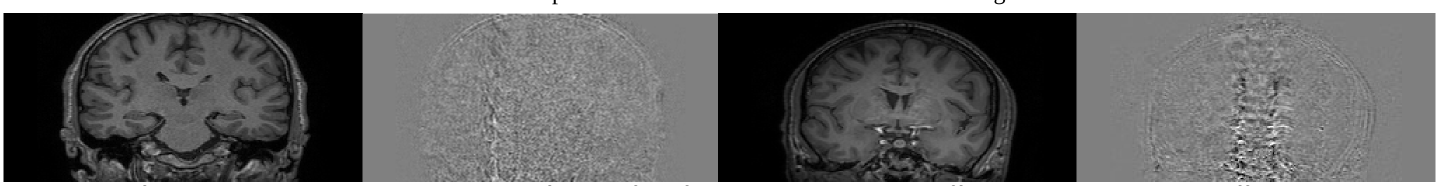

Figure 1 - Reformatted coronal slices with most severe flow artefacts from Volunteer 10: 1.5T, difference image at 1.5T, 3T, difference image at 3T

Discussion

Flow artefacts that appear to arise from the carotid siphons dominate the 3T subtraction images; the most pronounced flow artefacts were located within 2cm of the midline, although clear artefacts were also visible further laterally. At 1.5T the artefacts are less pronounced and in 9 of the 10 pairs of 1.5T images lateral artefacts seemed more prominent than medial ones. These patterns were found using both birdcage and array coils. Sagittal slab acquisition reduces these artefacts substantially. This study has illustrated and quantified some of the difficulties of transferring image acquisition and analysis protocols from 1.5T to 3T and of carrying out studies that aggregate data from 1.5T and 3T scanners. Further investigation is needed to minimize this effect.

References

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