Degraded water suppression in 1H-MRS due to shimming; a visualisation method and a comparison of shimming methods

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Abstract

Water gives approximately 10 000 times more signal than the metabolites of interest in a 1H MRS measurement, and hence must be suppressed. To achieve good spectral resolution in spectra, the volume of interest (VOI) is shimmed. With shimming small magnetic field gradients of first or higher order are added to balance the local magnetic field variations in a prescribed VOI. However, the shim gradients are global which mean they will affect the resonance frequency globally. Therefore the water resonance in some regions may be shifted outside the water suppression bandwidth, i.e. the water suppression becomes spatially selective. A region of unsuppressed water in the excitation slices of the volume selection is a potential source for the spurious echo artefact [1]. **The aim** was to design a scan that can visualise regions unaffected by the water suppression in the spectroscopy measurement. This scan was used to study the effects of different shimming strategies on water suppression in *in vivo* 1H MRS of the brain; comparing iterative and calculative methods and, first and second order calculative shim. Two different *in vivo* VOI locations in the brain were studied, and measurements were performed on both 1.5T and 3T.

Material & Method

The default MRS water suppression sequence, a double CHESS, was used as a pre-pulse to a single shot TSE, with TE=70 ms, resolution of 3x5mm and 5mm slice (1.5T) or 3x3mm and 3mm slice (3T). This scan is denoted "wsi-scan". The wsi-scan was tested on 6 healthy volunteers on two MR-systems, one 1.5T and one 3T, both Philips Achieva release 2.5. The standard transmit head coil was used. On the 1.5 T system iterative and calculative shimming was compared and on the 3T-system linear and second order calculative shimming. The shimming and water suppression were optimised on two different VOIs, 1) a 40x10x10 mm VOI in the right centrum semiovale and 2) a 10x10x15 mm in the right caudate nucleus. A reference wsi-scan where the RF-pulses of the water suppression pre-pulse were turned of was also acquired.

The wsi-scans were evaluated using MIPAV [2], where the image stacks were segmented into signalling and suppressed voxels and the fraction of suppressed volume was calculated as the quotient of signalling volume in the wsi-scan and the signalling volume of the reference wsi-scan.

Result

Figure 1 shows a typical coverage of the water suppression for the VOI in the right caudate nucleus. The repeatability amongst the volunteers was very good and for the same shimming method the wsi-images were very similar for all volunteers. The mean of the relative water suppressed volumes for the different field strengths and shimming methods are shown in figure 2. The error bars indicate the maximal and minimal values in the six volunteers.

Discussion & Conclusion

The wsi-scan proved to bee a good way of visualising the water suppression regions. It was possible to see the combined effects of the shim gradients and any local susceptibility induced magnetic fields. The water suppression never covered the entire head and when using higher order shimming on the small VOI in the susceptibility influenced caudate nucleus more then half of the brain was left unsuppressed. Even though the water suppression in the VOI is still good the large regions of unsuppressed water outside of the VOI will most probable cause a spurious echo artefact.
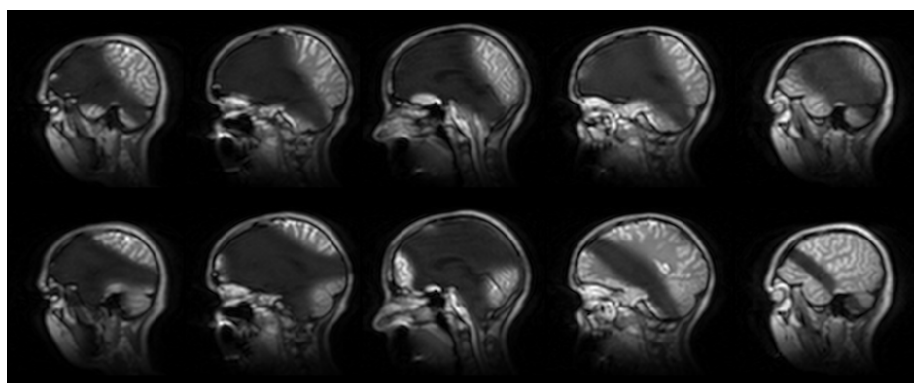

Fig 1. Five sagital slices from the 3T wsi-scan using shimming and water suppression optimised on the small VOI in the right caudate nucleus. The upper row shows water suppression coverage when using calculative linear shimming and the lower row shows water suppression coverage when using calculative second order shimming.

Fig 2. The mean water suppression volume (%) of the head for the two MRS VOIs and the different shimming methods, linear iterative shim (LI), linear calculative shim (LC) and second order calculative shim (SC).The error bars indicate maximal and minimal values.

References

1. Starck et al., NMR Biomed 2008, ahead e-publication, DOI: 10.1002/nbm.1289
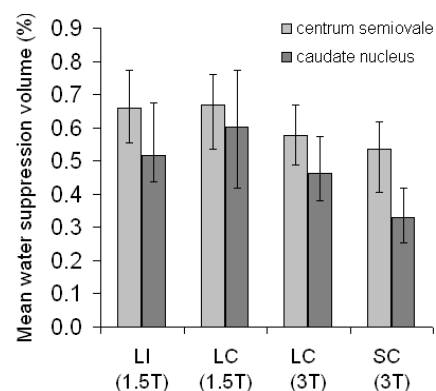2. McAuliffe et al. IEEE computer-based medical systems (CBMS) 2001, 381-386.