TrueForm Retains the Spectral Integrity on the MAGNETOM Verio

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Introduction

It is well known that good quality spectra are dependent on the magnetic field homogeneity of the magnet. The field homogeneity, in turn, is dependant on the magnetic field strength, the bore design etc. In the case of the MAGNETOM Verio, a 3T wide and shorter bore scanner, these factors are of concern for the spectroscopy community. The Verio uses an innovative technology known as "TrueForm". In TrueForm the two ports of the CP body coil are unequally fed with a non-orthogonal phase difference which causes an improvement in homogeneity as well as a reduction in power deposition. TrueForm design in the Verio mitigates the homogeneity effects that are normally experienced with both a wide and shorter bore at the magnetic field strength of 3T. This innovation was made possible by innovations in the magnet design, gradients, RF, acquisition and processing protocols. The TrueForm magnet design produces a cylindrically optimized homogeneous volume and a cylindrical shape for the gradient linearity volume. Here we demonstrate that the Verio, equipped with TrueForm, allows for spectroscopy to be undertaken satisfactorily for brain and breast.

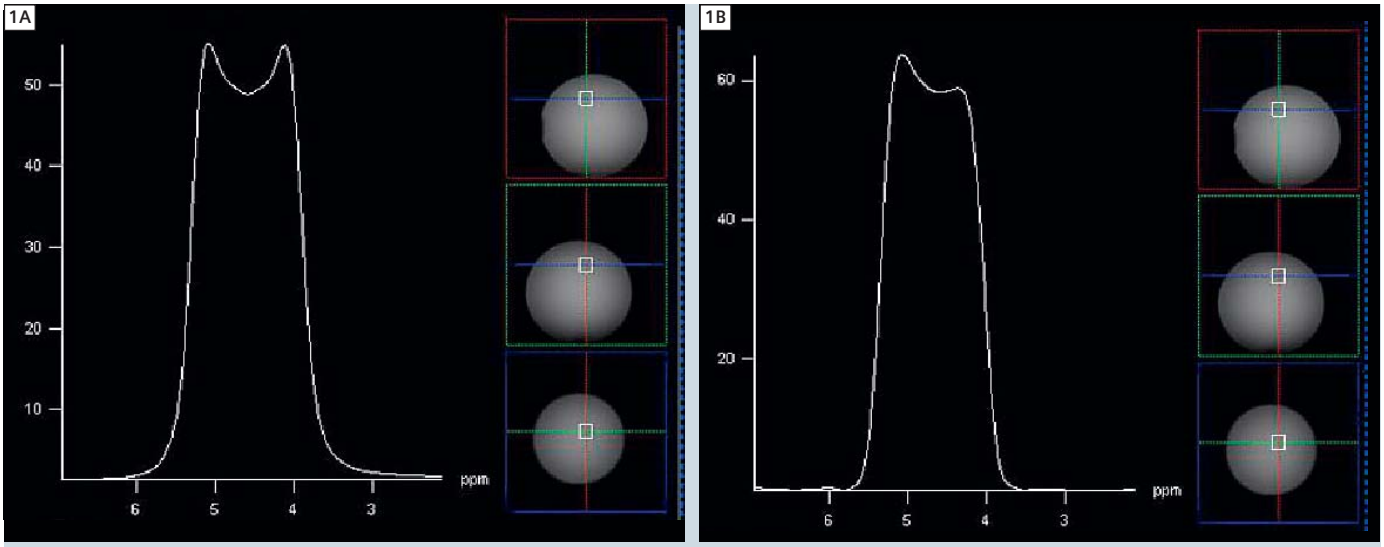
1. Spatial profile with standard spectral RF pulses (sinc and Mao)

Spatial profile of an RF pulse reports on its system performance (transmitted RF and gradient performance as well as magnetic field homogeneity). In Figure 1 the shape of a 90° (sinc) pulse and an 180° (Mao) pulse is shown. That the gradient linearity and B_1 homogeneity are acceptable is evident in the width of the profile and the near rectangular shape of the profiles.

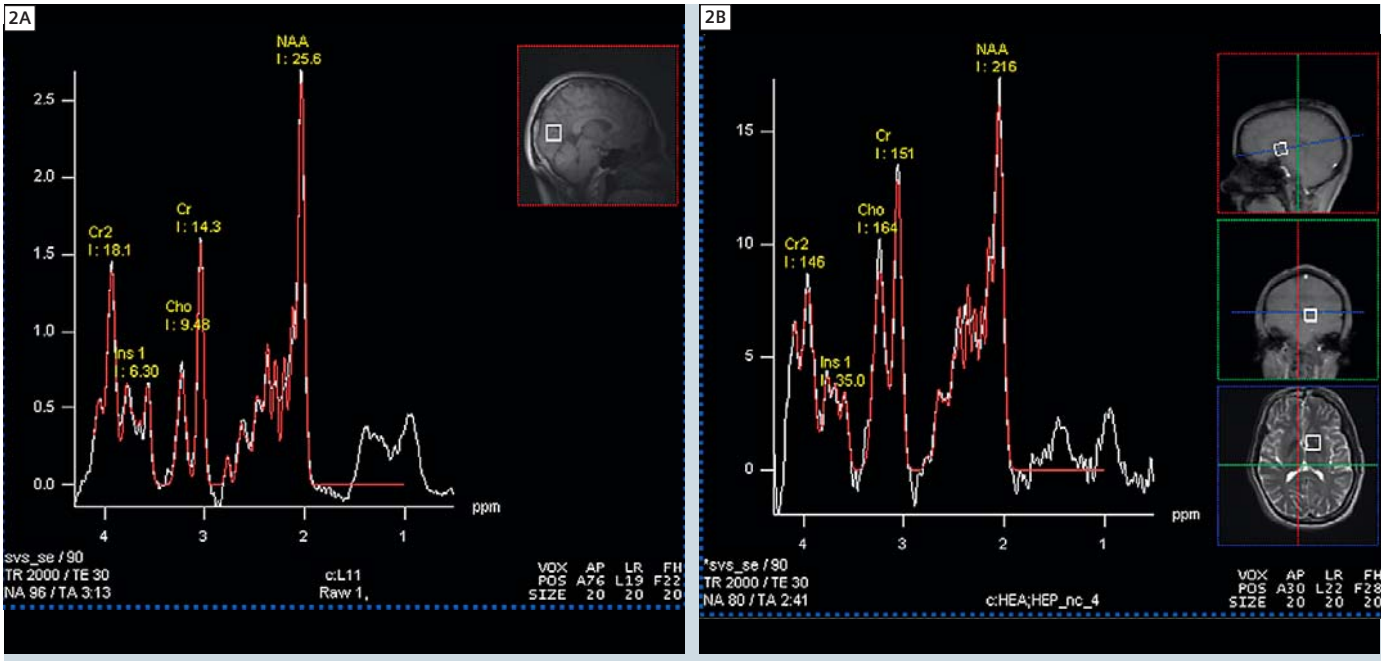
2. Neuro spectroscopy acquired with a loop coil and a head array coil

The MAGNETOM Verio performs neurospectroscopy well. On the left, in figure 1, is a svs_se (single voxel spectroscopy, spin echo) spectrum acquired with body coil excitation and the 11 cm loop coil for detection. Of note are a narrow line width at half-height, i. e. spectral resolution, and low lipid contamination especially with the loop coil. Localized shimming, a function of many multiple interacting factors (RF homogeneity, magnet design and gradient design) was achieved very well with a line width at half height of NAA (2 ppm) of 4 Hz. Efficient slice definition, spectral excitation and unwanted signal spoiling are important requirements in order to achieve these results. Utilizing the head array coil spectra could also be acquired from challenging locations within the brain, especially near nasal cavity and sinus (Fig. 1) without compromising the signal-to-noise ratio (SNR) and without lipid contamination.

Spin-echo chemical shift imaging, CSI_SE, was also implemented on a healthy volunteer to test the efficacy of localized shimming and lipid suppression from a wider region of interest (Fig. 3). It would appear that the TrueForm method is able to deliver efficient outer-volume suppression (OVS) pulses.



1 The profile of a 2.6 ms 180° Mao RF pulse (left), and a 2.6 ms 90° sinc RF pulse (right) accrued using a head array coil on the MAGNETOM Verio. The performance of these pulses are evident as seen as the profile width at half-height, which corresponds to 2 cm at the applied read-out gradient.

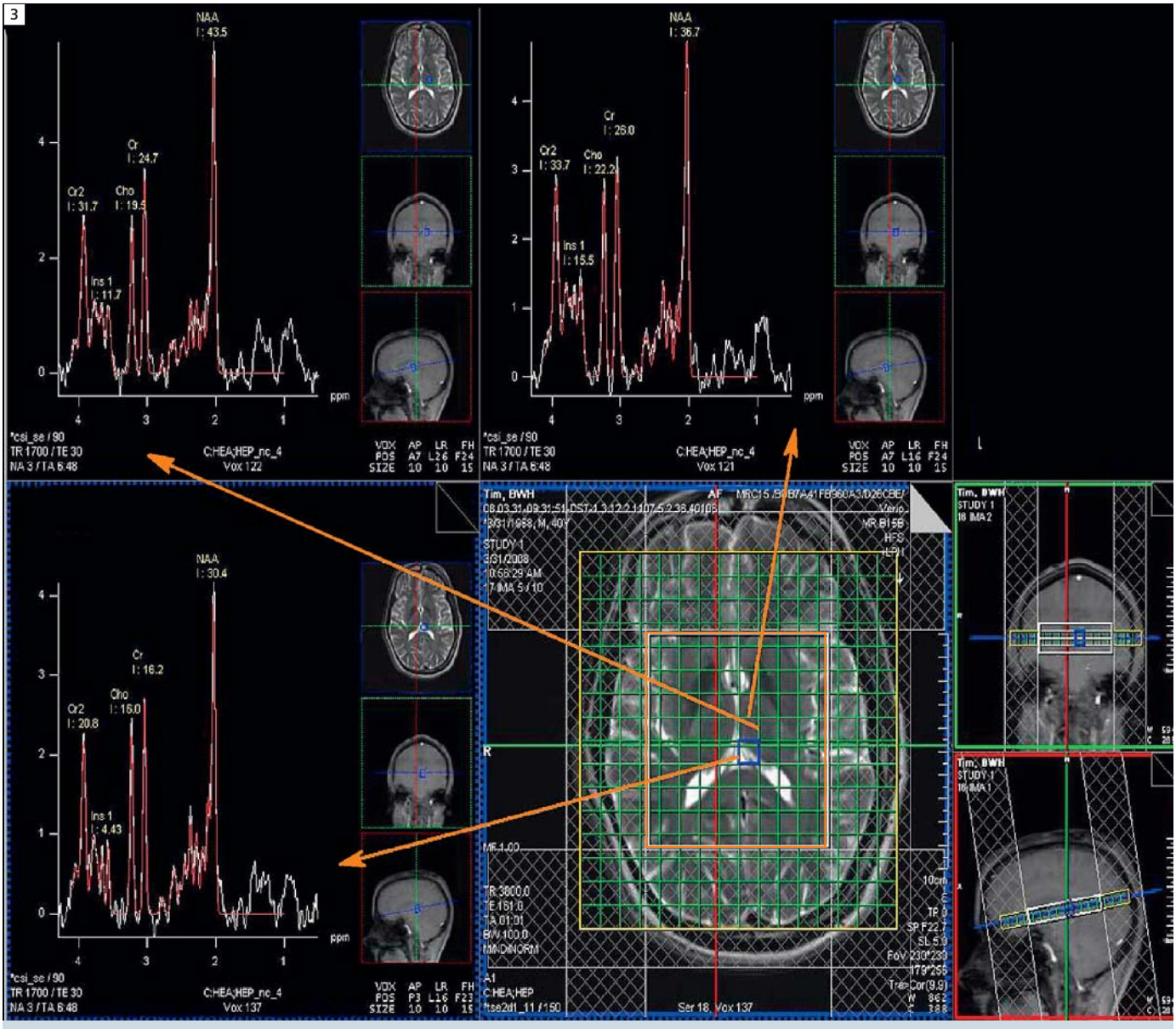


2 Standard, short TE, double-echo (SVS_SE) spectroscopy. (Left) SVS_SE is applied in the occipital lobe region of the brain, using a Siemens single-channel 11 cm loop coil. (Right) Short TE SVS_SE is applied in a challenging region of the brain, near the nasal cavity resulting in a good quality spectrum.

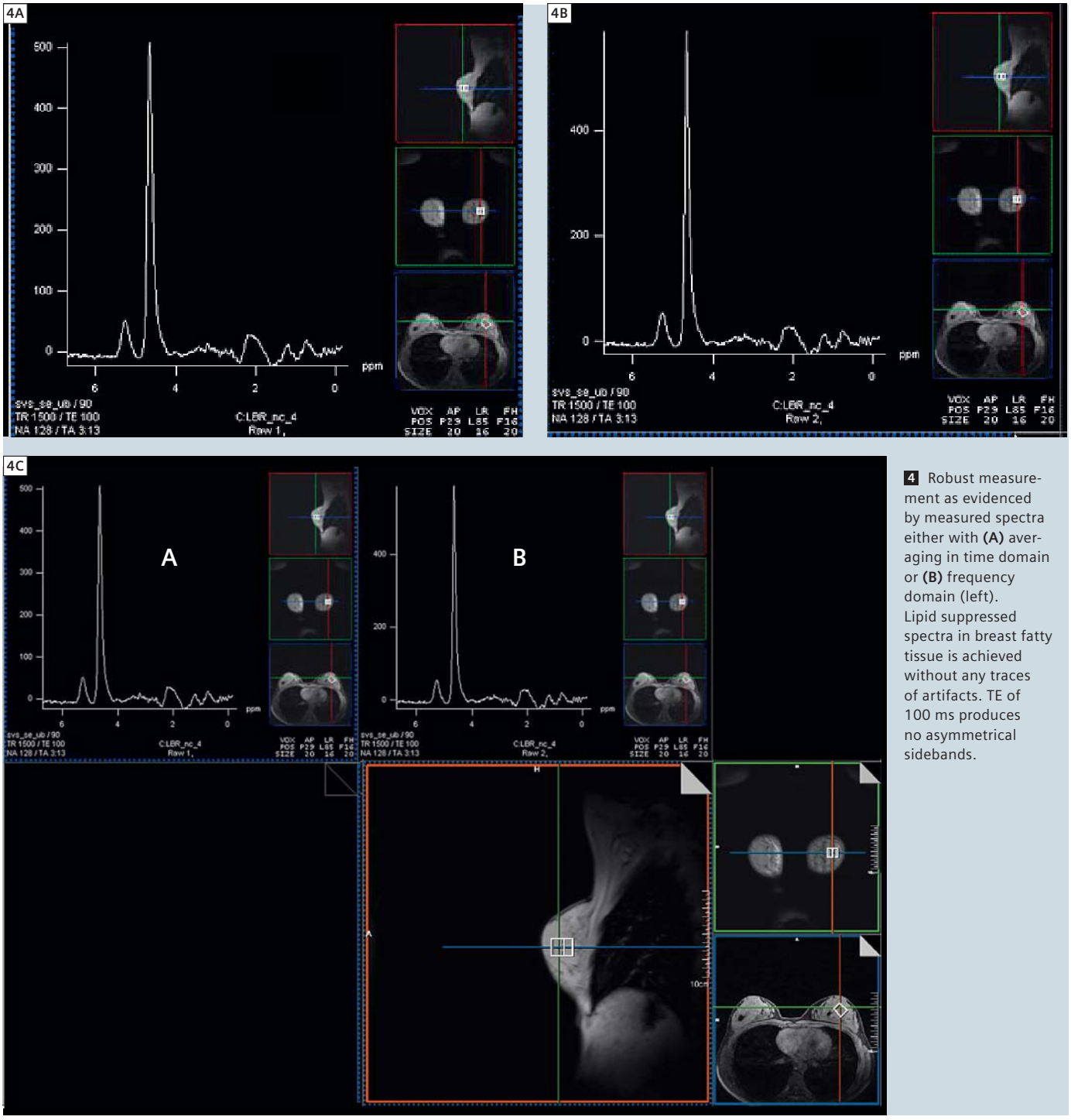
Similar observations to Fig. 2 apply to Fig. 3, where narrow line width, acceptable SNR, high spectral resolution and low lipid contamination were realized. Considering the small voxel size (1 x 1 x 1.5 cm^3) in this particular csi_se with 3 averages, the spectral quality is an improvement when compared to the quality obtained with traditional RF waveforms.

3. Breast spectroscopy

The capacity to collect in vivo spectroscopy from the breast using lipid suppression was also tested on the MAGNETOM Verio. The method successfully suppressed the lipid resonance at 1.30 ppm using MEGA pulses [Mescher et al., 1998]. A voxel (20 x 16 x 20 mm^3) was prescribed in the breast of a healthy volunteer. The universal body version of SVS_SE (svs_se_ub) was used to check for stability during the acquisition of the 128 averages. Thus, these averages were averaged in time domain (traditional) and in spectral domain after individual Fourier transforming [Gabr et al., 2006]. In Fig. 4 the same FID is presented using two different types transform, and the difference in nil; a sign of stability. The large lipid peak suppressed without inducing any spectra artifacts (e.g. baseline roll). Anti-symmetric peaks [Bolan et al., 2002] were not observed at a TE of 100 ms.



3 Shimming is integral for successful spectroscopy and this is especially the case for multi-voxel CSI. The quality of 16 x 16 grid 2D CSI data (left) and the resolution of the resonances illustrate good B_0 homogeneity. We conclude that the homogeneity is not compromised by the wider bore or that the TrueForm technology compensates.



4 Robust measurement as evidenced by measured spectra either with **(A)** averaging in time domain or **(B)** frequency domain (left). Lipid suppressed spectra in breast fatty tissue is achieved without any traces of artifacts. TE of 100 ms produces no asymmetrical sidebands.

References

1 Bolan, P. J., Delabarre, L., Baker, E. H., et al. 2002. Eliminating Spurious Lipid Sidebands in 1H MRS of Breast Lesions. Magn. Reson. Med., 48: 215–222.

2 Gabr, R. E., Sathyanarayana, S., Schar, M., et al. 2006. On Restoring Motion-Induced Signal Loss in Single-Voxel Magnetic Resonance Spectra. Magn. Reson. Med., 56: 754–760.

3 Mescher, M., Merkle, H., Kirsch, J., et al. 1998. Simultaneous in vivo spectral editing and water suppression. NMR. Biomed., 11: 266–272.

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