The Twisted coil: A New Strip Array Coil Topology for 3D SENSE

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Abstract: In this work, a new planar strip array coil topology is presented. It allows one to use SENSE in two phase-encoding directions* and hence significantly decreases the scan time for a 3D image without increasing the number of receiver channels.

Method: Multi-channel coils are aimed at reducing g-factor for parallel imaging. While development has proceeded with larger arrays of smaller coils, this work is focused on improving the spatial encoding efficiency from a limited number of coils. A straight cylindrical strip array** coil cannot accelerate in z (Fig. 1). However, by twisting the striplines (Fig. 2), we rotate the coil sensitivity profile in the xy-plane as we move along z, such that the aliased data for a given coil element do not overlap in z upon acceleration (Fig. 3).

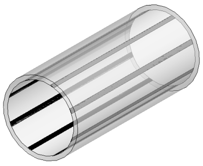

Fig. 1: Straight coil

Fig. 2: Twisted coil (twist angle=270°)

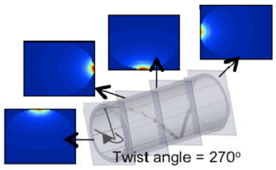

Fig. 3: Coil Profiles in the xy-plane along z (twist angle=270°)

Computer simulation: Simulations have shown that for an acceleration factor of 4 or higher, the g-factor map for an accelerated 3D image is better if we accelerate in 2 directions (y and z) compared to only y. We compare on Fig. 4 and 5 an accelerated image and the associated g-factor map obtained with a straight coil with those obtained with a twisted coil for an acceleration factor of 8. One can see that it is advantageous to be able to accelerate along y and z since the g-factor mean is really less important for the twisted coil than for the straight coil. The g-factor for the twisted coil is very high at the center of the xy-plane because the coils share the same information.

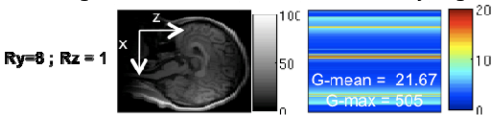

Fig. 4: SENSE reconstructed images and their associated g-factor maps for a straight strip array coil

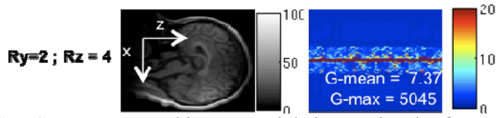

Fig. 5: SENSE reconstructed images and their associated g-factor maps for a twisted strip array coil (twist angle = 270°)

The twist angle is an important parameter in the design of the twisted coil. On Fig. 6, we compare the g-factor mean of a twisted coil (acceleration along y and z: red curves) with the one obtained with a straight coil (acceleration along y only: blue curves). One can see that the g-factor mean of the twisted coil decreases if the twist angle is increased since the coil profiles are more different from one slice to another. However it should be less than 360 degrees so that the coil profiles along z do not share the same information.

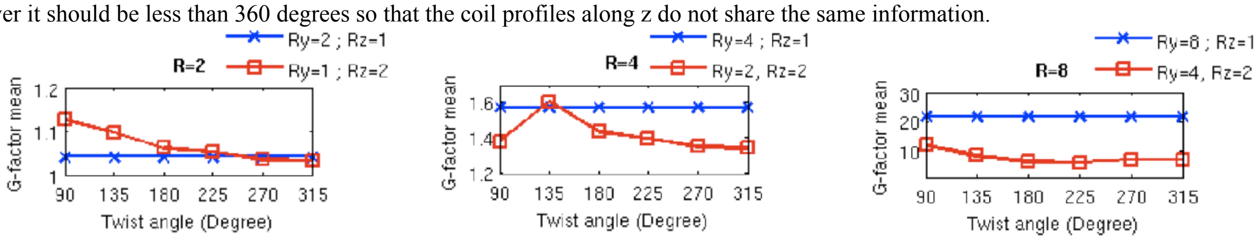

Fig. 6: Influence of the twist angle on the g-factor mean for an acceleration factor R of 2, 4 and 8

It is important to note that the magnetic field B1 of the striplines is no longer entirely in the xy-plane if the lines are twisted along z. This has an influence on the SNR since fewer signals would be transmitted and detected. To quantify the impact of the twist angle, we compare the SNR of an accelerated image of a straight (blue curves) with the SNR of an accelerated image of the twisted coil (red curves): Fig 7. These results have been normalized to the SNR of a straight coil without acceleration. We consider for this study that the coils have a diameter of 5.6 cm and a height along z of 12 cm. For an acceleration factor higher than 4, the twisted coil presents higher SNR than the straight coil, even with the reduced sensitivity due to the twist angle.

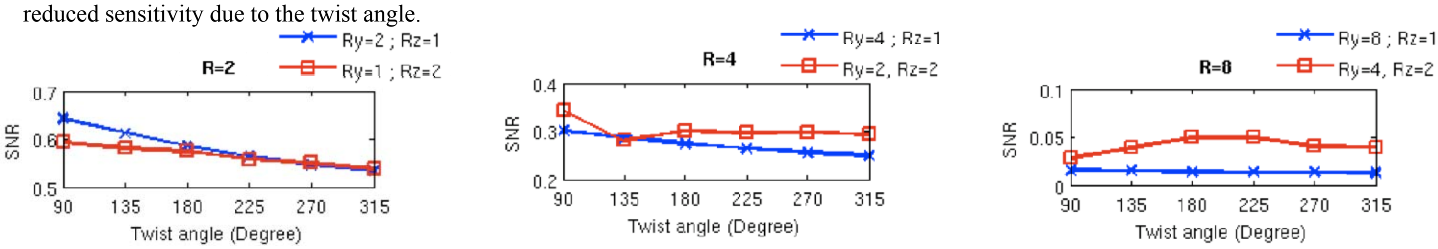

Fig. 7: Comparison of the SNR of the twisted strip array coil with the straight strip array coil for an acceleration factor R of 2, 4 and 8. The results are normalized to the SNR of a straight strip array coil without acceleration

Discussion: The initial results obtained with the twisted coil demonstrate increased acceleration and better SNR for 3D acquisitions without the need to add addition receiver coil channels. It is worth noting that this study assumes that the striplines length are small compared to the wavelength since it has been done for a small coil at 3T. That means that the magnetic field amplitude does not vary along z. For a head coil size (and/or higher fields), such approach could be scaled up using a segmented 32 channels (8*3) coils stacked end-to-end.

References: * Weiger M, Pruessmann KP, Boesiger P., "2D SENSE for faster 3D MRI", MAGMA. 2002.

** R.F. Lee, C.R. Westgate, R.G. Weiss, D.C. Newman, P. A. Bottomley, "Planar Strip Array (PSA) for MRI", Magn Reson Med. 2001 April.