Experimental verification of enhanced B1 Shim performance with a Z-encoding RF coil array at 7 tesla.

G. Adriany[1], J. Ritter[1], T. Vaughan[1], K. Ugurbil[1], and P-F. Van de Moortele[1]
[1]Center for Magnetic Resonance Research, University of Minnesota Medical School, Minneapolis, MN, United States

Introduction:

In recent years the field has made remarkable progress addressing a number of difficult RF related issues that arise at 7 tesla and above [1-4]. However, homogeneous whole head coverage and spin excitation in areas of the lower temporal lobe and the cerebellum is still difficult to achieve at 7 tesla. Previously a 32 channel transceiver array coil design [5] based on short strip line transceiver elements was presented that addressed this problem by allowing for B_1 manipulation along the z- direction. Here we describe a modification of such a coil that supports visual task presentation within the spatial constrains of a narrow head gradient coil. To verify the enhanced B_1 shim performance of this z -shim array we compared the latter coil with a standard 16 channel stripline array with matching spatial coverage.

Methods:

Our 7T system (Siemens, Erlangen, Germany) supports up to 16 independent transmit channels and allows for phase and amplitude shim using 16x 1 kW RF amplifier (CPC, NY,USA). The transceiver array consisted of 30 transmission line elements of 8 cm length arranged in two concentric rings to cover the upper (16 elements) and lower part (14 element) of the head. A second coil was built for the comparison and had 14 elements of 16 cm length and 2 elements of 8 cm length covering the frontal cortex. Otherwise same holder geometry (20x24 cm^2), conductor width (12mm), radial conductor position and teflon substrate thickness (12 mm) were used for both coils (Fig. 1). Decoupling capacitors reduced next nearest neighbor interaction and were used in both coils [6]. For a fair comparison with the 16 ch array, we utilized only 16 out of the 30 elements of the z-shim array, choosing 8 elements of the upper concentric ring and 8 elements of the lower concentric ring. Identical methods were used for B1+ calibration [7] and B1 shim. The B1 shim target was manually drawn on three coronal slices encompassing all brain tissues (including the cerebellum and the lower temporal lobe). B1 phase shim solutions were calculated in Matlab to homogenize |B1+| in the pre-defined target. RF efficiency maps, defined as the resulting |B1+| map divided by the sum of each element |B1+| maps, were calculated for each B1 shim solution inside the B1 shim target. The same complete procedure was performed within a same session and with the same subject who was carefully positioned similarly in both coils.

Results and Discussion:

We were able to establish flexible use of the 30 elements of the z-shim array and we could reduce the number of utilized coil elements to 16, which also corresponds to the RF shim capabilities of our system. The noise correlation matrices obtained with both coils (Fig. 2) indicate satisfactory decoupling between coil elements. The correlation coefficients are in average lower in the z-shim array, which we attributed to the larger distance between elements. Although very high RF efficiency can be obtained with local B1 phase shim when applied on a target of small size, B1 shim methods can become very inefficient when large targets are considered. Thus, to evaluate the potential increase in B1 shim performance with the z-shim array, we choose a large B1 shim target extending over 3 brain slices, including location that typically suffer from weak transmit B1 (cerebellum, lower temporal lobe) (Fig.3). RF efficiency is a critical metric to estimate B1 shim performance with an RF array, as it inversely correlate with RF power, and thus with SAR level. As can be seen in Fig. 3, satisfactory B1 shim could be obtained with both RF arrays. However, the corresponding RF efficiency was significantly higher with the z-shim array, a substantial advantage with regards to SAR. This promising result is consistent with simulations showing improved B1 shim with multiple rings of elements along Z [8].

References:

[1] Wiggins, G.C., et al., *MRM*, 2005. **54**(1): p. 235-40. [2] Adriany G. et al, *MRM* 2005. 53(2):434-45 . [3] Vaughan, T., et al., *MRM*, 2006. **56**(6): p. 1274-82 [4] Ledden, P., et al.,in *Proc. 15th ISMRM* 2007: p. 242. [5] Adriany, G. et al. *In Proc. 15th ISMRM* . 2007,p.166 [6] Wang, J.*in Proc. 4th ISMRM* 1996 p.1434. [7] van de Moortele P-F. et al.in *Proc. 17th ISMRM 2009*, p 367 [8] Mao, W., et al., MRM, 2006. **56**(4): p. 918-22.

Acknowledgements:

EB 00331, EB 000895, P41 RR008079, P30 NS057091, W.M. Keck Foundation.

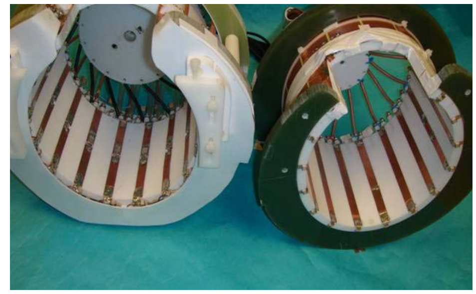

Fig.1 Photograph of the Z-shim array (left) and the 16 ch. array (right)

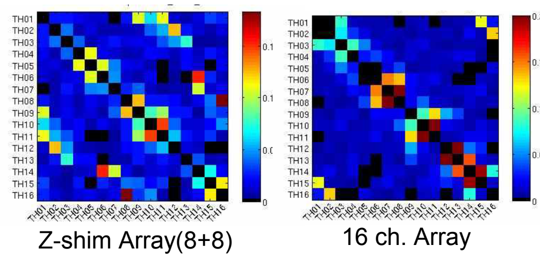

Fig. 2 Noise Correlation Matrices

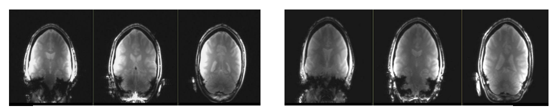

Fig. 3 Coronal views after B1 shim with the Z-shim array (left) and the 16 ch array (right)

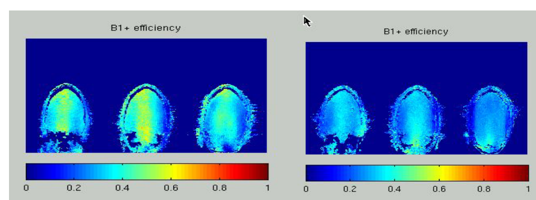

Fig. 4 RF Efficiency with the Z-shim array (left) and the 16 ch array (right) corresponding to the B1 shim solutions applied in Fig. 3.