48 Channel Body / Spine Matrix Coils for 3 Tesla

V. Matschl[1], A. Reykowski[1], K. Jahns[1], M. Hergt[1], H. Fischer[1]
[1]MREC-LC, Siemens Medical Solutions, Erlangen, Germany

Introduction:

In analogy to the 1.5 Tesla Body/Spine Matrix coil concept [1] a new 3.0 Tesla version is presented. 48 loop elements (24 anterior elements using 4 Body Matrix coils and 24 posterior elements of the Spine Matrix coil) allow the simultaneous coverage of thorax, abdomen and pelvis at 3.0 Tesla. Data acquisition can be done in two steps with each step covering a maximal FoV of 500mm. The so called "Matrix coils" allow the use of a scalable number of receivers as a function of desired acceleration factor for parallel imaging and/or desired SNR in peripheral regions as well as to the installed number of independent system receiver channels [2].To show the parallel imaging performance, relative SNR loss maps on phantoms are calculated. Based on these results volunteers were examined.

Methods:

The Spine Matrix consists of 24 independent channels of which a maximum of 12 fit into a 500mm FOV. Up to four 6 channel Body Matrix coils can be combined with the Spine Matrix for whole body coverage in conjunction with other Matrix coils. Each coil – Spine Matrix and Body Matrix - has several sets of three independent array elements in x-direction, the so called clusters. In z-direction all these clusters are equally dimensioned. Thus, anterior and posterior Matrix clusters can be matched up against each other in z direction.

Using a Mode Matrix combiner network, the three signals from each cluster are internally recombined to three new mode signals. Using proper recombination for such a network, the total information and therefore SNR and spatial information is preserved [2,3]. The primary mode signal correlates to the circularly polarized signal and the two additional mode signals (secondary and tertiary) carry the rest of the information needed for parallel imaging or for improving the SNR in the periphery of the object.

Because of the well-known 3 Tesla challenges for coil design (shortened wave length, increased E-field), unwanted coupling and parasitic capacitances between individual loops and neighboring wires have been minimized. In addition, the spacing between cable traps was reduced and the attenuation of each trap was increased to further reduce unwanted shield currents. Besides the fact that local coils have to tolerate much higher RF stress at 3T, the Tim Technology™ allows every coil to be placed at variable positions inside the magnet bore. For coils outside the isocenter and close to the end rings of the body coil the induced RF can be significant higher than in isocenter position. Therefore, additional detuning circuits had to be implemented and extensive RF stress testing had to be performed to ensure patient safety and component reliability.

Results:

Investigations were carried out on a 3.0 T Siemens Trio scanner with Total imaging matrix technology.

For the SNR and g-factor evaluation, an oil phantom surrounded by a body loader (height: 22cm; width: 32cm) was scanned with a standard spin echo sequence. Using MatLab™ (The MathWorks, Natick, MA), maps of relative SNR (SNR per unit time) and relative SNR loss (SNR loss factor =1/[g-factor]) were calculated.

Fig. 1 demonstrates the relative SNR loss for Triple mode operation (all 3 mode signals per cluster acquired) and acceleration factor 3 with PE direction left-right using the Spine and Body Matrix. Here, the SNR loss constitutes only 14% in the middle of the phantom.

The PAT performance of the new Matrix coils was evaluated with a volunteer and adequate sequences (Figs.2-3).

Fig 2. shows a T2 FLASH with short breath-hold (TA=0:29min, PAT=2). The accelerated image contains no visible artifacts and is well illuminated with complete fat suppression.

Fig. 3 shows a T2 TSE whole CNS done in 2 steps with total FoV=797mm, TA=3:06min and PAT=4. The image was obtained with a combination of Head (12 Channels), Neck (4 Channels) and Spine (24 Channels) Matrix coils, illustrating also the advantage of the matrix concept in terms of combinability of Matrix coils to achieve extended coverage with a high coil density.

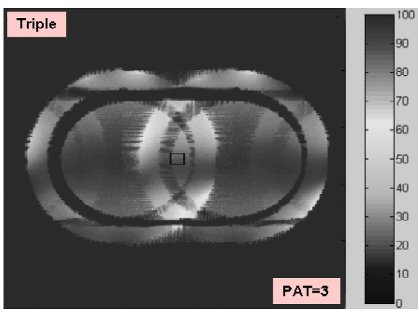

Fig. 1) 1/g map for PAT=3 with PE left-right

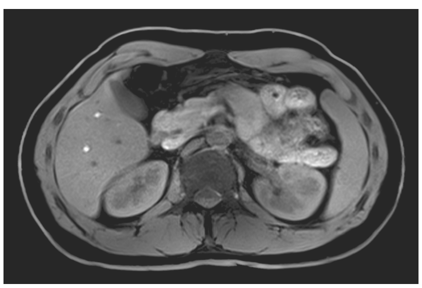

Fig. 2) T2 FLASH with breath-hold

Fig. 3) T2 TSE whole CNS

Conclusion:

Designing 3.0 Tesla Body and Spine Matrix coils is a challenge that goes well beyond the task of just retuning the equivalent 1.5 Tesla Matrix coils. Special care has to be taken at the higher frequency in terms of suppression of shield currents and parasitic capacitive coupling between neighboring wire structures.

With the presented Body and Spine Matrix coils a single FoV of 500mm can be acquired with 8, 16 or 24 receiver channels in CP-Mode, Dual Mode or Triple Mode (1, 2 or 3 mode signals per cluster). Examinations on human volunteers with acceleration factors of up to three and phase encoding left-right deliver superb clinical images with short TA. Also, the expected two-fold SNR gain over 1.5T could be confirmed.

The ability to combine Body and Spine Matrix coils with other Matrix coils (Head, Neck, PA) allows to extend the FoV up to whole body coverage with high coil density, high penetration depth and uniform illumination over each single FoV [4].

References:

[1] Matschl V. et al., Proc. ISMRM 12th Ann. Meeting, Kyoto, 2004, p. 1586.
[2] Reykowski A. et al., Proc. ISMRM 12th Ann. Meeting, Kyoto, 2004, p. 1587.
[3] King, S.B., et al., Proc. ISMRM 11th Ann. Meeting, Toronto, 2003 p. 712.
[4] Reykowski A. et al., "16 Channel Head / Neck Matrix Coils for 3 Tesla", submitted to ISMRM Annual Meeting, Miami, 2005.