Comparison of a TEM Head Coil with an 8 Channel Head Array Coil at 3 Tesla

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Introduction Over the last years an increasing number of 3T MRI scanners have emerged as valuable clinical and research tools. To exploit the inherent advantage of an enhanced signal-to-noise ratio (SNR) at higher fields, dedicated hardware, such as transverse electromagnetic (TEM) volume radiofrequency (rf)-coils, have been developed (1). These TEM coils have been successfully utilized at $B_0 \geq 4T$ (2,3). The goal of this study was to evaluate a TEM head coil in comparison with an 8 channel head array coil on a clinical 3T MRI system. In conclusion, results indicate favorable SNR values for the 8 channel coil at the cost of increased image intensity variations and rf-power deposition.

Methods Based on the description in (4), phantom and human brain data were acquired using a TEM head coil (transmit/receive, MR Instruments Inc., MN, USA) and an 8 channel head array coil (receive only, Siemens Medical Solutions, Erlangen, Germany) on a 3T scanner. Both coils had similar geometric dimensions. Initially, sagittal gradient echo (GE) images across the center of a cylindrical mineral oil phantom were acquired with the following scan parameters: TR/TE=2000/3.6, *matrix*=128x128, square *FOV*=240 mm, slice thickness=5 mm, α=10°, *BW*=260 Hz/pixel, and *NA*=1. These images and their 1D intensity profiles were used to define the slice positions, which showed the strongest MR signal intensity along the axial direction of the coil, for acquiring transversal GE images using the same scan parameters, except for a modified TR (TR=5000 ms for phantom, TR=1000 ms for human head). A long TR and a small flip angle were used to avoid any saturation effects. No image intensity correction was applied. Experimental parameters including positioning were kept the same throughout the entire evaluation. For the human head scans, coil positioning was adapted, such that the same anatomy was imaged at the most sensitive axial location of each coil. The SNR was measured in five different regions-of-interest (ROIs) of the transversal slices. In addition, MR signal intensity variation (SIV) was calculated as $SIV=(|SI_C - ASI_p|/ASI_a)*100\%$, where SI_C is the image intensity in the center ROI, and ASI_p and ASI_a are the average image intensities of the four peripheral and of all five ROIs, respectively.

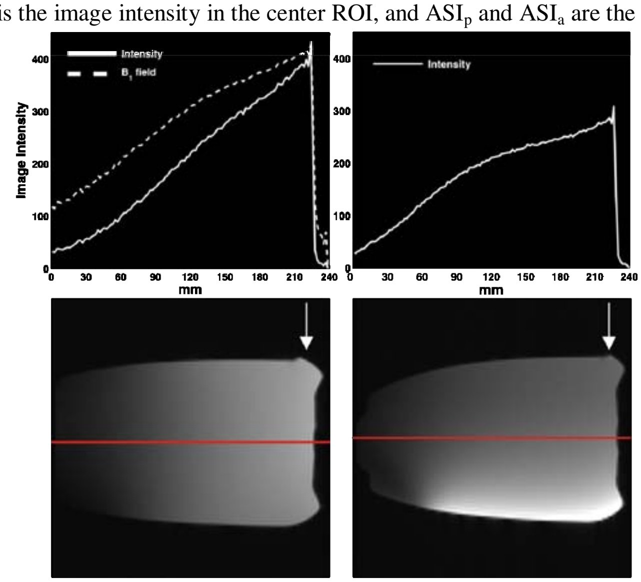

Fig. 1: *Upper row*: 1D profiles through the center of a phantom used to determine the most sensitive region along the axial direction of each coil. *Lower row*: Sagittal GE images acquired with both coils. Arrows indicate the respective location of the transversal slice shown in Fig. 2.

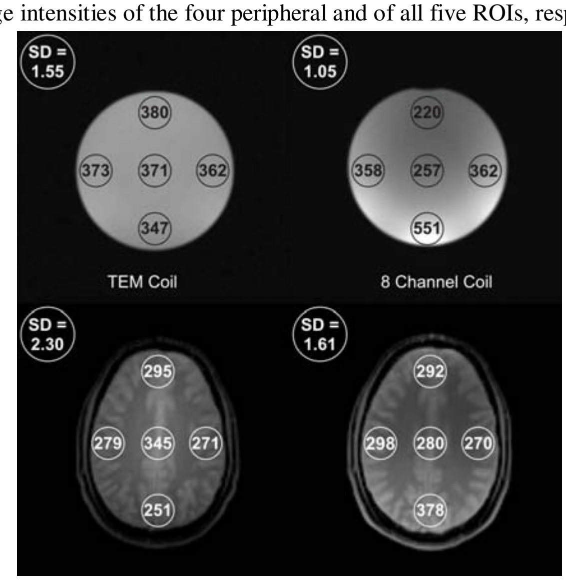

Fig. 2: Transversal GE images acquired with both coils. *Upper row*: Mineral oil phantom. *Lower row*: Human brain data. Average image intensities are given for each ROI, except for the ROI used to measure noise, where the standard deviation (SD) is shown.

Results As seen from Fig. 1, both coils had their most sensitive axial region towards their superior end. Note that for the chosen scan parameters, image intensity is proportional to B_1^2 for the TEM coil (B_1 profile indicated by dashed line in Fig.1), which does not hold for the 8 channel coil. In images acquired with the latter, a strong intensity gradient along the transverse direction was observed, which was absent in results from TEM coil scans. This observation was qualitatively and quantitatively confirmed by the phantom data shown in Fig. 2, for which SIV=1.4 % and SIV=33.3 % for the images obtained with the TEM and 8 channel coil, respectively. Although image intensity was equal or larger for almost all ROIs in TEM compared to 8 channel data (see Fig. 2), the increased noise value resulted in a somewhat reduced SNR. Mean SNR for phantom and for human head images was reduced by 29.4% and 33.4%, respectively. For single ROIs though, the SNR of TEM data was even increased (phantom) or the difference in SNR was as low as 13.6% (human). These results showed that signal reception (and transmission) with the TEM coil was much more homogeneous over a transversal slice. In contrast, image intensity correction was indispensable to improve the homogeneity of 8 channel coil images.

Discussion Lower SNR values despite increased intensities in images acquired with the single channel TEM coil are largely due to the noise averaging that takes place during image reconstruction of multi-channel data (sum of squares for magnitude images). Nevertheless, benefits from using a TEM coil at 3T include excellent image quality, superior (uncorrected) image homogeneity, and reduced rf-power deposition. The latter enables acquisitions of an increased number of slices in certain cases, since only specific absorption rate (SAR) limitations for the head, instead of those for the body, have to be considered. Finally, more demanding applications requiring rf-fields with large ($\gamma \cdot B_1/2\pi$) values, e.g. MR imaging and spectroscopy techniques that employ adiabatic rf-pulses, can only be realized using a TEM coil instead of a combination of body and 8 channel coil.

References and Acknowledgements (1) J.T. Vaughan et al, MRM, 32(2), 206-218, 1994; (2) J.T. Vaughan et al, MRM, 46(1), 24-30. 2001; (3) A.M. Abduljalil et al., J. Comput. Assist. Tomogr., 23(3),335-340-18, 1999; (4) X. Zhang et al., JMR, 161(2), 242-251, 2003. ---- This study was supported by the Centre d'Imagerie BioMédicale (CIBM) of the UNIL, UNIGE, HUG, CHUV, EPFL and the Leenaards and Jeantet Foundations.