Computational comparison of two RF coil configurations for SENSE imaging

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Synopsis. The ultimate factor g was used to theoretically compare performance of two coil geometries for SENSE imaging. The circular SNR formula based on the quasi-static model was used, and the PERES coil SNR was calculated following the same approach. These expressions together with the ultimate factor g formula were used to compute ultimate-factor-g-vs-distance plots for comparison purposes. The PERES coil factor g can be up to 27% below that of a single circular-shaped coil. This improvement makes PERES coil a good choice for SENSE imaging. The present method strengthens the g simulation approach to evaluate coil performance for SENSE applications.

Introduction. The SENSE technique exploits the spatial information generated by receiver coil array coils for signal localisation in order to reduce gradient encoding. Image noise is enhanced locally as a result of reduced gradient encoding when the used coil array does not provide ideally distinct spatial sensitivities. This effect usually becomes relevant for reductions larger than a factor of two. It can be quantitatively described by the so-called geometry factor g. In addition to conventional array development considerations the geometry factor g must to be taken into account. Although *g* is difficult to estimate intuitively, it has been found that relatively basic simulations can give a good forecast of the performance of a certain array configuration. In this research, the *ultimate factor g* proposed by [1] is used to compare the coil performance of a circular-shaped coil and the PERES coil [2] for SENSE imaging.

Method. Reykowski [1] has recently calculated an analytical expression for the ultimate factor g for 2 ideal coils:

$$g^{ultimate} = \frac{SNR^{full}}{SNR^{SENSE}} = \left(1 - \left|\frac{S_{12}^2}{S_{11}^2}\right|\right)^{-\frac{1}{2}} \quad [1]$$

where S_{11} and S_{12} are the SNR of coils 1 and 2 at point 1 respectively. Eq. [1] shows that the ultimate factor g depends on the coil SNR. To compare the coil performance of these two coil design, the quasi-static model described in [3] was used to calculate a mathematical formula for the SNR of PERES coil (Eq. [2]), and the single-loop coil SNR (Eq. [3]) was also obtained from [3]:

$$SNR_{PERES} = \frac{MV\cos(\omega)}{\sqrt{(kT\,\Delta f\,\sigma)}}\sqrt{\frac{3N}{16l\,(b_{PERES}^2+d^2)^3}} \quad [2], \qquad SNR_{cir} = \frac{MV\sqrt{b_{cir}}}{\sqrt{(b_{cir}^2+d^2)^3}}\sqrt{\frac{3}{16kT\,\sigma\,\Delta f}} \quad [3]$$

where *M* is the magnetisation density, *V* is the voxel volume, b_{cir} is the circular coil radius, *d* is the depth at a given point *p*, Δf is the bandwidth of the receiver low-pass filter, *k* is the Boltzmann constant, σ is the conductivity of half-space, and *T* is the temperature of the loss resistance. In Eq. [2], ω is the angle representing the centre of the coil of radius a_{petal} (petal coil radius) relative to the coil of radius b_{PERES} (total radius), $l\ a_{petal} = b_{PERES}$ (total radius), and *N* = number of petal coils. MatLab (V. 6.1, The MathWorks, Natick, MA) programmes were specially written to calculate the ultimate factor g profiles for these two RF surface coils. To assess the performance of these coils, ultimate g expressions were calculated for both coil configurations by substituting Eqs. [2] and [3] in Eq. [1] with $\omega = 0$ for the case of two points as shown in Fig. 1.

Results and Discussion. The g profiles of the two coils were computed with reduction factor R =1, $b_{PERES} = b_{cir}$= 10 cm, and the following parameters, *d* (coil 1): 0< *d* < 10 and d_{pha} -*d* (coil 2): 0<. d_{pha} -*d* <10. g-vs-*d* plots were then obtained and shown in Fig. 2(left). To evaluate coil performance an improvement plot was also estimated and shown in Fig. 2(right). It can be appreciated from Fig. 2 (left) that the factor g of the PERES coil shows a considerable improvement over the single-coil profile. Results of Fig. 2 (right) indicate that there is no evident change for the factor g for points near the surface coil (Coil 1 or Coil 2) according to the layout of Fig. 1, and that the upper limit of PERES coil factor g is about 27% below the factor g of the circular coil for distant points. An important limitation is that a coil SNR expression is required. To find an analytical expression for the SNR is a difficult task since coil designs can take very complicated configurations. These results are in good agreement with those reported in [4]. The PERES design shows better performance than the circular coil for SENSE imaging applications. Unlike the computationally-demanding and time-consuming simulations, the ultimate factor g expression offers a straightforward way to predict coil performance for SENSE techniques.

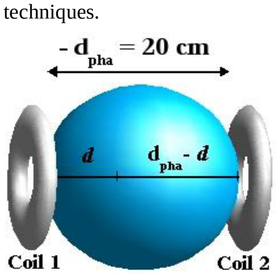

Figure 1. Two points along the diameter in a lossy half space for the quasi-static model.

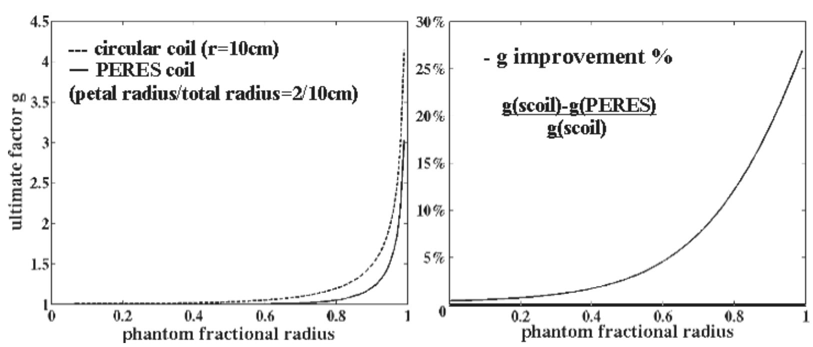

Figure 2. Left) The lower g profiles of PERES coil shows improvement coil over the circular coil. Right) Improvement profile shows the 27% upper limit.

References

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