Comparison of image quality between open and cylindrical systems

K. Ham[1], M. Warntjes[1], S. Gulpers[1]
[1]Philips Medical Systems, Best, Netherlands

Introduction. In the past the image quality of open MR systems was considered as inferior, mainly because of their low field. Recently, mid field open MR systems have been introduced with field strengths of 0.6-0.7T. In recent years MR manufacturers are developing 1T open systems. The signal-to-noise ratio (SNR) of the receive coils of a 1.0T open MR system (vertical field) have been compared to those of cylindrical systems (horizontal field). Most of the coil elements of open MR system coils enclose the object, whereas for a 'cylindrical' coil the elements form loops at the surface of the object. Since these enclosing coil elements have a higher filling factor, their SNR is generally better [1,2]. This has been both measured and simulated.

Methods. The SNR of a vertical and a horizontal field system has been compared on one single system. This eliminates differences in SNR, due to differences in hardware (gradients, RF-system and even RF coil) or in software. The images have been made on a 1.0T open system (Philips Medical Systems). The different field orientation has been simulated by changing the orientation of the phantom and adapting the coil layout. A body/neck phantom has been used. A two-element synergy coil has been applied at the neck region of this phantom (cylindrical shape, 16cm diameter). For the 'vertical field' imaged, the phantom was oriented with its axis in horizontal direction and the coil elements were placed around the neck. For the horizontal field images, the phantom axis was vertical and the elements were positioned aside the neck region. See figure 1.
Three contrasts have been scanned (T1W, T2W and PDW). The region where the SNR has been measured is indicated in figure 1.

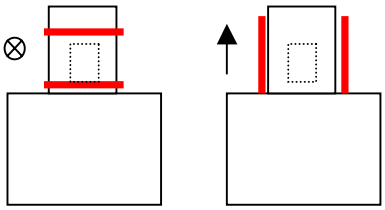

Figure 1: Phantom and coil lay-out for vertical field (left) and horizontal (right); arrows indicate direction of B_0

Results and discussion. The PDW images are shown in figure 2. The images with the other contrasts are similar. An intensity profile over the phantom axis is shown. The SNR over a central region of interest has been measured and the ration of SNR vertical/horizontal has been calculated. The results can be found in table 1. The average ratio of the SNR vertical/horizontal is 1.29.

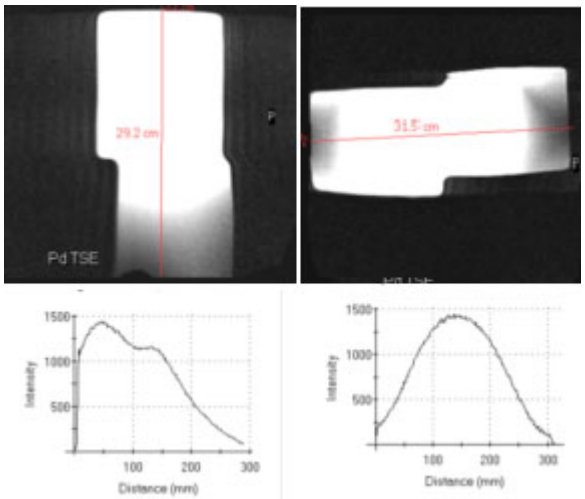

Fig 2: PDW images for vertical field (left) and horizontal field (right) and signal profiles over the lines as indicated in the images

Table 1: imaging	T1W	T2W	PDW
SNR 1.0T vert. field	101.62	37.6	86.56
SNR 1.0T hor. field	73.24	29.6	71.01
Ratio SNR vert/ hor	1.39	1.27	1.22

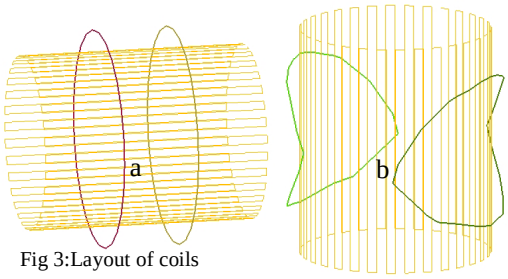

Fig 3:Layout of coils

This experiment has also been simulated for 3 system types: 1.0T horizontal, 1.5T horizontal and 1.0T vertical. The phantom and coil layout are shown in figure 3. The phantom is a cylinder with 16cm diameter. The elements are assumed to have zero capacitive and inductive coupling. Noise correlation is taken into account. The calculation of the H-field is based on Biot-Savart. Noise is calculated through a volume integral of the induced E-fields squared in combination with the noise of the coil elements themselves. The result is show in table 2. The SNR of 1.0T vertical is a factor 1.28 higher than 1.0T horizontal for this particular coil and phantom. This is in good comparison with the experimental result. The SNR of 1.0T vertical (coil as fig 3a) is almost equal to the SNR of 1.5T horizontal (coil as fig 3b).

Table 2: simulation	1.0T horizontal	1.5T horizontal	1.0T vertical
SNR in center	47.0	63.3	60.1

The calculated SNR on the phantom axis is shown in figure 4. This shows a good comparison with figure 2, except that the measured profile is asymmetric due to the influence of the body section. The profile for the vertical field coil has a flatter shape than for horizontal field coil, resulting in an additional gain in SNR for larger FOV's.

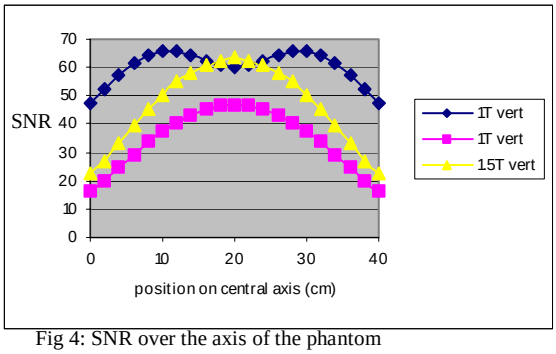

Fig 4: SNR over the axis of the phantom

References [1] Xu et al. Mag Res Med 49:551-557 (2003)
[2] Ballon et al. Mag Res Imag 7: 155-162 (1989)

Conclusion. The imaging results and the simulation show the same trend. The receive coils for a vertical field system are more efficient than the ones for horizontal field systems. The SNR of a 1.0T vertical field system (coil as fig 3a) is comparable to a 1.5T horizontal field system (coil as fig 3b).