Comparison of Four Different Birdcage Type Coils

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INTRODUCTION: Four birdcage-type coils that were previously modeled (1) were built to examine the effects of end-ring/shield configuration on the signal-to-noise ratio (*SNR*) in a human head. The coil configurations included a) a conventional cylindrical shield (conventional), b) a shield with annular extensions to closely shield the end-rings (surrounding shield), c) a shield with annular extensions connected to the rungs (solid connection), and d) a shield with strips of copper tape connected to the rungs(thin wire connection).

METHODS: The mechanical support structures of the four coils are the same (D_{coil}=26.05cm, D_{shield}=35.56cm, Length=20.32cm). All coils were built as 12-rung linear low-pass birdcage-type coils but with different end-ring/shield configurations (Fig. 1). Three capacitors in series were distributed along each rung, except the rungs attached with variable tuning and matching capacitors, to tune the coil to 125.44 MHz. An inductive driving loop was used for the thin wire configuration to decrease the imbalance introduced by the matching circuitry. Q values were measured at –3 dB points on the transmission return loss curve on a network analyzer. T2-weighted head images of five axial, sagittal, and coronal slices of a healthy Asian male subject (30yr, 170cm, 79.4kg) were acquired on a 2.94 T Bruker MedSpec S300 system with four coils and same RARE (2) sequence (TR=4680ms, TE=80.4ms, matrix size=256×256, NEX=2, FOV=25×25cm^2, 5-mm thick slices with a 0.5mm gap between slices, and RARE factor=8). *SNR* was measured by dividing the signal, which is averaged over all brain tissues, by the standard deviation of background noise in the image plane. All *SNR*s are normalized to the *SNR* in the conventional configuration. The input RF power is also normalized to that in the conventional coil.

RESULTS: The images of the axial, sagittal, and coronal slices passing through the center of the coil for the four coils loaded with the subject's head are shown in Figure 2. The Q values, input RF power, and *SNR* in the central axial, sagittal, and coronal planes in the head are listed in Table 1 for each coil.

DISCUSSION: The surrounding shield configuration results in the highest *SNR* in the central axial plane and the thin wire configuration results in the lowest, which agrees with previous calculations (1). Although there is no significant difference between the overall *SNR* of the conventional configuration and the surrounding shield configuration, the surrounding shield configuration has less inductance, and thus has the potential to be tuned to higher frequencies than the conventional configuration. The solid connection configuration has a lower *SNR* than the conventional and the surrounding shield configurations probably due to higher sensitivity to the perturbation of the matching circuit (3). The input RF power used by the coils is consistent with the *SNR* performance of the coils. Q values for loaded and unloaded cases are within reasonable range but there is no relation between the ratio of $Q_{unloaded}$ to Q_{loaded} and *SNR*.

REFERENCES:
1) W Liu et al. MRM 51:217-221 (2004)
2) J Henning et al. MRM 3:823-833 (1986)
3) J Tropp. Proc. ISMRM p 1129 (2001)

Table 1. Q values, RF power (*P* in dB), and *SNR* in the head for the four coils. The RF power is measured for a 3.2 ms 90 degree gauss pulse during head imaging and normalized such that the power used by the conventional coil is equal to 0 dB.

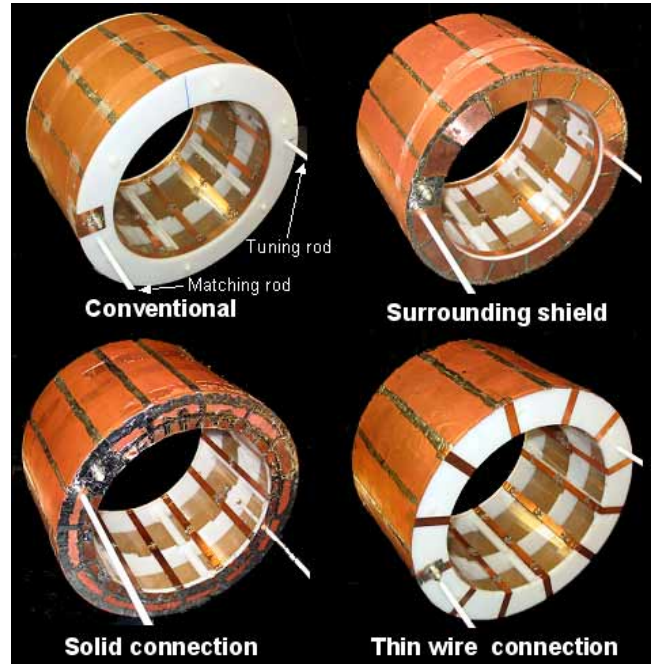|	Q		*P* (dB)	*SNR* in the head		
	Unloaded	Loaded		Axial	Sagittal	Coronal
Conventional	128	20	0	1	1	1
Surrounding	162	40	0	1.04	1.02	0.961
Solid connection	222	40	0.9	0.958	0.848	0.903
Thin wire connection	248	48	2.5	0.761	0.738	0.755

Figure 1. Four 12-rung low-pass linear birdcage-type coils with four different end-ring/shield configurations.
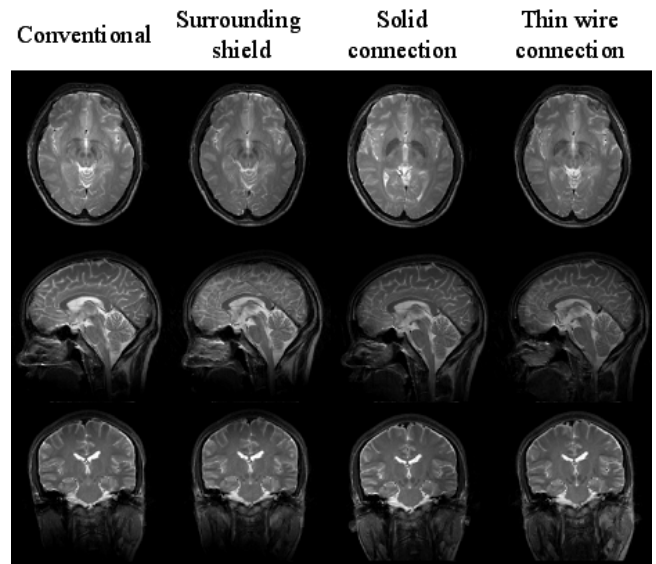

Figure 2. T2-weighted images of the same subject's head acquired with the four coils in the same magnet.