Shielded And Unshielded High-Pass And Hybrid Birdcage Resonators For Use At 3T And Above: A Comparison

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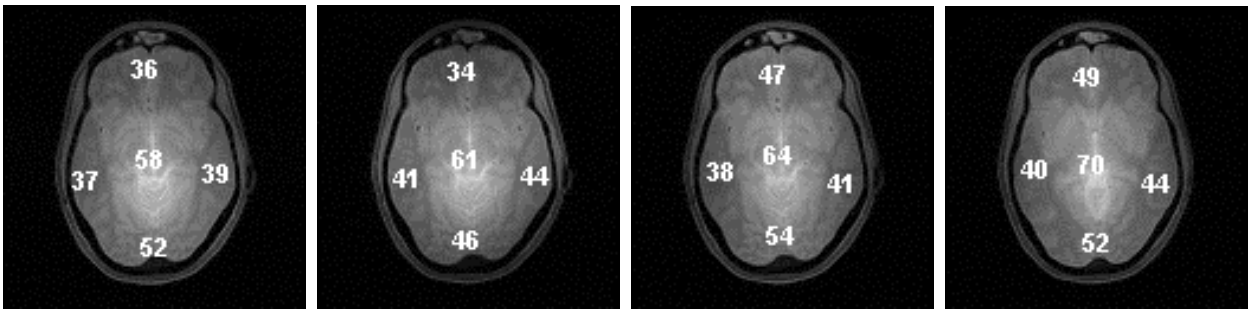
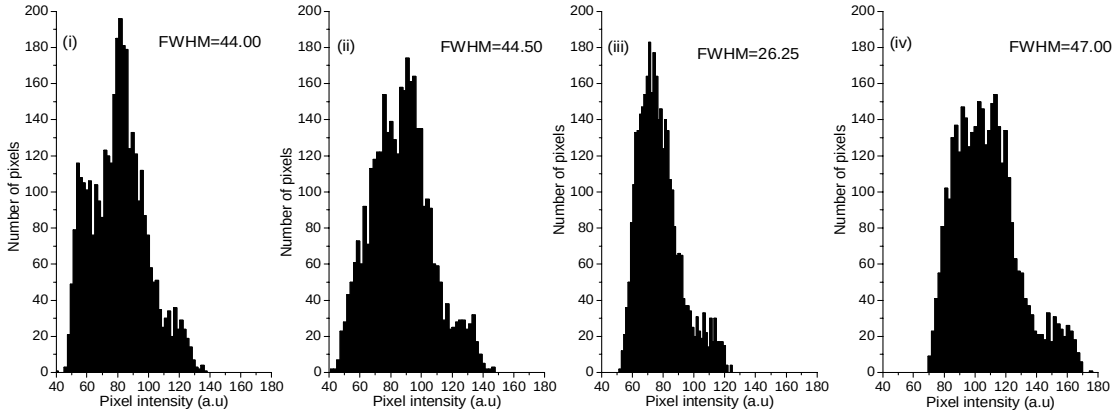
Introduction: Technological developments from high field NMR are migrating from research to clinical applications. High field clinical NMR of the head at 3T and above may make use of high field resonator designs that inherently reduce radiative and electric field losses while maintaining a clinically acceptable, non-claustrophobic, shieldless, open design where no significant coupling to head gradient inserts mandates shielding. Four identically dimensioned birdcage volume resonators for head imaging at 4T were compared: (i) an unshielded high-pass birdcage, (ii) shielded high-pass, (iii) an unshielded hybrid birdcage and (iv) a shielded hybrid birdcage. The hybrid birdcage resonator is a combination of low-pass and high pass lumped element capacitors, uniformly distributed around the birdcage structure such that continuous conductive element lengths are < $\lambda/20$.

Experimental Details and Results: All four resonators were 50 ohm matched and tuned to 170.3MHz (4T) *in-situ* on a human volunteer. Resonator element lengths are 21 cm, the resonator former O.D. is 28 cm, and the former I.D. is 26.5 cm. The isolation between the quadrature ports in all designs are greater than -20dB and the reflection coefficient is also greater than -25dB. Multiple Gradient Echo (GE) images were also acquired on a low dielectric Oil phantom and loader shell set, with the signal producing phantom being 15 cm in diameter to assess integral uniformity of all four designs. Integral uniformity for (i) 11.5%, (ii) 12.4%, (iii) 7.7 and (iv) 6.1% were measured.

Multiple Gradient Echo (GE) images were acquired on a healthy volunteer with the following parameters: gradient echo, TE = 3.1ms, TR = 1000ms, flip = 11.25 deg, 24 cm fov, 5 mm thick slice. Figures given below (i), (ii), (iii) and (iv) shows human head transverse images acquired using the unshielded high-pass, shielded highpass, unshielded hybrid, and shielded hybrid respectively, with SNR values as shown and their corresponding histogram of pixel intensity below. The width of this histogram is the measure of RF homogeneity in the volume coil (the smaller the width higher the homogeneity).



(i)unshielded highpass (ii) shielded highpass (iii) unshielded hybrid (iv) shielded hybrid



Images acquired using high-pass design birdcage resonators show less signal intensity at the top of the image compared to the other peripheral positions, whereas in the hybrid design, the signal intensities at the peripheral are of the same value. This demonstrates that the images obtained with the hybrid resonator have superior image uniformity in human head images than those obtained with the high-pass design. The histograms of pixel intensity on human brain images confirm the unshielded hybrid coil is an appropriate choice for high field applications, with the best homogeneity and excellent SNR relative to the designs compared.

Conclusion: The unshielded hybrid birdcage resonator provides excellent RF homogeneity and sensitivity in high field head imaging applications where an open, unshielded coil design is preferred, and when no significant coupling to gradient coils is anticipated. High SNR and uniformity is achieved with the unshielded hybrid design bird cage volume coil.

[1] Barberi et al, MRM 2000; **43**:284-289.