Broadband Tunable Birdcage Coil for Rat Head MRI at 21.1 Tesla

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Introduction

While ultra-high magnetic fields such as 21.1 Tesla (^{1}H f_0 = 900 MHz) may offer a range of opportunities for high resolution MRI, construction of a volume RF coil accommodating a wide range of sample conditions is still a challenge. Since its introduction in 1985, the birdcage coil [1] has become the geometry of choice for a vast array of MRI applications. Tuning of the conventional birdcage coil is often achieved by adjusting the capacitance across one or two legs. This tuning scheme may lack the range to work with samples of different dielectric properties and sample loads. It also introduces angular asymmetry to the B_1 field. The tuning range is further reduced as the number of legs is increased to achieve higher B_1 field homogeneity. In this work, we study a birdcage coil that uses a sliding end-ring (SER) for broadband tuning at high B_0 fields. Tuning is implemented by the capacitive overlap between the legs of a birdcage and the moveable end-ring. Because overlap capacitance is varied simultaneously across each leg, broadband tuning is achieved without perturbing the angular symmetry of B_1 field. At high magnetic fields, such as 21.1 T, capacitance values become small enough for the application of common materials with a lower dielectric constant to achieve the required capacitive overlap.

Results and Discussion

Table 1 compares tuning properties of a conventional birdcage and the SER birdcage prototype. Both are formed on identical 35-mm OD PEEK cylinder. The conventional birdcage has 8 electroplated copper legs. The SER coil is built with 16 strips of copper tape serving as legs. The SER birdcage has a relatively low quality factor in the absence of load, but it has a comparable quality factor in heavily loaded conditions, for which the conventional birdcage may not tune. Without discrete chip capacitors, the SER birdcage does not require time-consuming soldering effort and is easier to construct with a larger number of legs to improve B_1 homogeneity. Fig. 1 shows multi-slice FSE images of a mineral oil phantom obtained from the SER and conventional birdcage coils in axial and coronal directions, respectively. For comparison, multi-slice FSE images are displayed in Fig. 2 from a heavy loading 1xPBS-agarose phantom. Fig. 3 demonstrates the utility of the SER design for high field MRI of large rodents.

Table 1	Conventional coil	Sliding ring coil
Q, no load	310	183
Q, H_20	53	46
Q, 90-mM saline	9	11
SNR, oil	238	291
SNR, PBS/gel	145	196

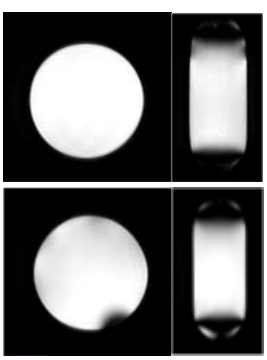

Fig. 1. FSE images of mineral oil in sliding ring (top) and conventional (bottom) birdcage coils.

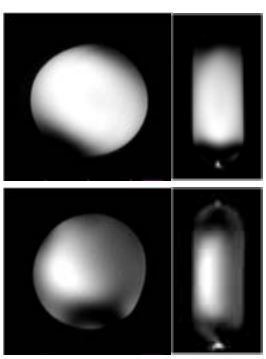

Fig. 2. FSE images of heavy loading 1xPBS-gel in sliding ring (top) and conventional (bottom) birdcage coils.

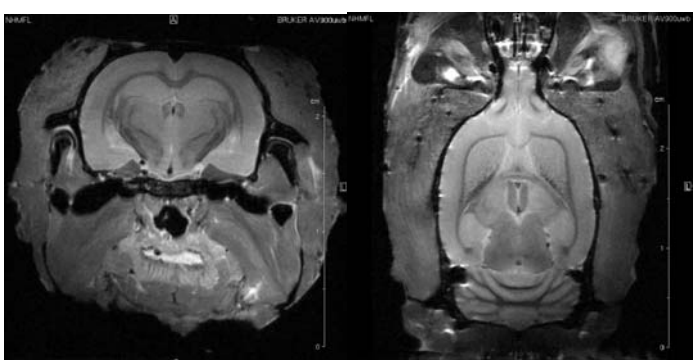

Fig. 3. The (left) coronal and (right) axial images of an *ex vivo* rat head, acquired at a 115x115x500 μm^3 resolution using new sliding end-ring coil.

In summary, the sliding end-ring design offers a tuning range that extends from an unloaded to heavily loaded condition, with minimal changes in RF homogeneity. Furthermore, SNR in the sliding ring coil is better than in the conventional birdcage.

Acknowledgements:

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References: [1] C.E. Hayes, *et al.*, J. Magn. Reson. **63**, 622–628 (1985).