A hybrid dielectric/birdcage double tuned volume resonator for high field MRI

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Target Audience. MRI coil designers, researchers working in high field musculoskeletal magnetic resonance.

Purpose. To design a new hybrid volume coil for sodium and proton imaging of the wrist at 7 Tesla.

Introduction. MRI-based investigations of diseases such as osteoarthritis and rheumatoid arthritis typically acquire both proton and sodium images. Here, a new type of double-tuned volume coil was designed by the imbrication of an HEM-mode dielectric resonator [1] and a conventional birdcage resonator [2]. The dielectric resonator acts as a proton transceiver while the birdcage acts as the sodium transceiver.

Methods. All experiments were performed using a whole body 7T MRI system. The hybrid resonator is based on reference [1] and consists of a concentric configuration of two plastic tubes used to form an annulus with dimensions 140 mm outer diameter, 90 mm inner diameter and a length of 153 mm. The volume between the two cylinders was filled with deionized water. The filled compartment was sealed and two square loops with a diameter of 50 mm were mounted on the outside of the resonator at 90 degrees to one another to excite the quadrature, degenerate HEM_{11} modes of the resonator. Variable capacitors were used for impedance matching to 50 Ohms at 298.1 MHz. Inside the dielectric resonator a 4 rung low-pass birdcage resonator (diameter 80 mm, rung length 89 mm, rung width 25 mm, endring width 13 mm) was tuned to 78.85 MHz for sodium, with proton parallel LC traps placed in each rung [3]. The birdcage resonator was capacitively coupled to the spectrometer via an LC network which matched the input impedance to 50 Ohms. A schematic of the hybrid resonator is shown in Figure 1A and a photograph in Figure 1B.

Results. In vivo images of the right wrist were obtained from four volunteers (three female, one male), as shown in Figurse 1(C-E). The volunteers lay laterally on the patient bed with the wrist positioned in the coil and the head resting on the right arm resulting in a comfortable position. The overall scan protocol is approximately 25 minutes. As shown in Figure 1, high resolution proton images can be easily fused with the sodium data, giving good depiction of the cartilage in the carpal bones.

Discussion and Conclusion. Dielectric resonators are a particularly attractive design for high field since they are based on continuous current distributions throughout the entire structure, rather than requiring a large number of discrete conducting elements with associated lumped elements for tuning. The resonance frequencies of modes with desirable magnetic field characteristics overlap the relevant Larmor frequencies for practical resonator dimensions. This works shows that dielectric resonators can be combined with conventional lumped element resonators to form double resonant volume coils. Results in vivo show easy integration and good performance from such an assembly.

References. [1] Aussenhofer SA, Webb AG. Magn. Reson. Med. 68:1325-1331 (2012). [2] Hayes, CE et al, *J. Magn. Reson.* 63, 622–628 (1985). [3] Matson GB et al. Magn Reson Med. 42:173–182 (1999).

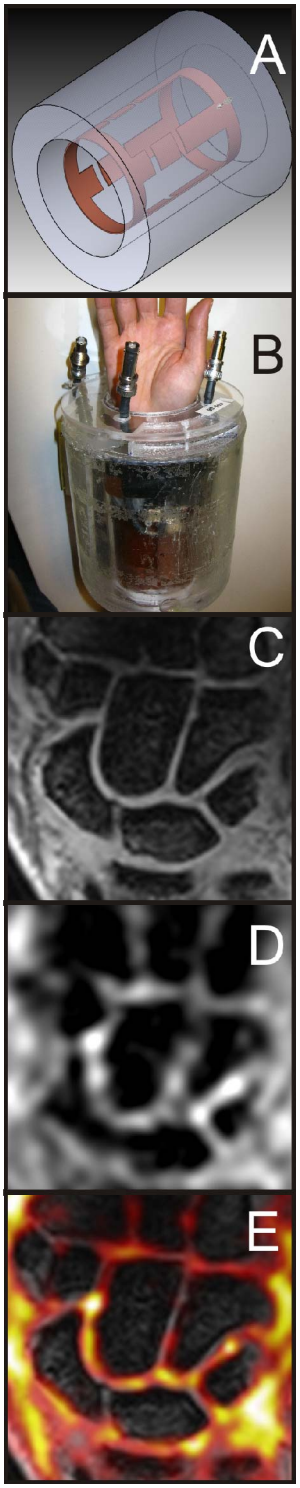

Figure 1 A) shows a CAD drawing of the water-based dielectric resonator (grey) with the four rung birdcage insert (brown). B) a photograph with a volunteers's wrist in place. C) In vivo data from the wrist: proton data were acquired with a voxel size of 0.75 x 0.75 x 2.0 mm (TE 3.0 ms, TR 10 ms, NSA 1, duration 2.75 min) and the sodium data (figure 1 D)) was acquired with 2.25 x 2.25x 3.0 mm isotropic resolution, TE 2.09 ms, TR 100 ms, NSA 13, duration 10 min). E) shows an overlay of the proton and the sodium images.