4T Split TEM Volume Head and Knee Coils for Improved Sensitivity and Patient Comfort.

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Introduction: Conventional high-field RF coils for the human head and limb are typically formed from rigid cylinders. For human legs, the opening of the coil must accommodate the foot. However this limits the minimum size and therefore, the efficiency of the coil. For brain studies in patients with impaired mobility, compliance or mild claustrophobia, this can present additional difficulties. Additionally when receive-only arrays are used within the transmission coil, the ability to both place and visualize the location of the array is limited. These limitations can be overcome using a split "two-piece" coil. Due to the presence of end ring RF currents, split unshielded birdcage (BC) coils (1) require a continuous electrical connection between two halves of the coil. For shielded RF coils, both the BC coil and the shield must be separated and reliably reconnected electrically during each use. However, TEM coils, due to the absence of end ring currents and the use of through-space inductive coupling between resonant elements (2), can overcome this limitation since the two halves of the coil do not require electrical continuity. Previous work by Vaughan et al (3,4) have proposed split TEM coils, however they provided no technical details or experimental data (3,4). In this work we report the detailed design, construction and performance of 4 T split TEM volume coils for the head and knee.

Methods: 16-element TEM knee (Figs 1A,B) and head (Figs 1C,D) coils were built using coaxial resonant elements (2). The leg TEM coil was 20 cm in length with an RF shield diameter of 25 cm and an element id of 21cm. The head coil used a closed end for improved RF homogeneity (21 cm in length, an RF shield diameter of 33 cm and an element i.d. of 27.5 cm). Both coils were driven in quadrature using a two-port drive (Fig.1). The coils were split in two parts (9 elements in the lower portion) with no electrical connection between them. In spite of small gap (1-2 mm) between the shields, the coupling between the elements adjacent to the split was reduced by ~40%. Placing an electrically insulated piece of shield, overlapping with both halves of the TEM (Fig. 1), increased the coupling to 75% of the original value. The side shields were located ~3 mm from the major shield (distance determined by plastic insulation) and measured 5 cm in width. The unloaded Q of the TEM coils were unaffected by the split and both measured better than 700.

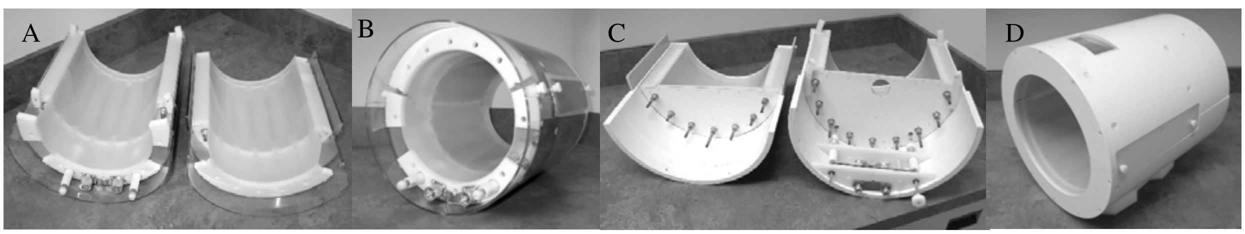


Figure 1 A),B) Knee split TEM; C),D) Head split TEM

Results and Discussion: Reductions in the inductive coupling between the elements also reduced the isolation between the two linear modes of the quadrature TEM coil thus the coil performance. To restore the isolation between the modes and the performance of the coil, the capacitance of resonant elements was adjusted (pulling out central rods of the top and bottom elements). Fig.2 shows the distribution of current in elements of the TEM leg coil for one of the linear modes (5). Decreasing the capacitance of top and bottom elements decreased the current in these elements in comparison to the elements located on the sides of the coil. A similar effect was seen for the TEM head coil. Maps of the transmit B_1 field (6) also showed a 10% decrease in field at the top and the bottom of the coil as compared to the left and the right sides of the coils. This did not substantially affect the image quality (Fig. 3). The split leg coil was ~20% more efficient than the one-piece open-end leg TEM which accommodates a foot, (shield od – 33cm, element id – 27.5cm, length – 20cm). The TEM head coil provided identical performance to a conventional "one-piece" closed-end TEM of the same size.

Figure 2 The distribution of currents in elements of the TEM leg coil

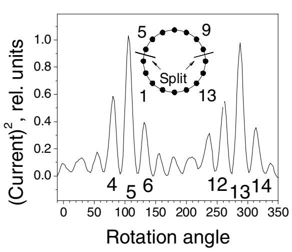
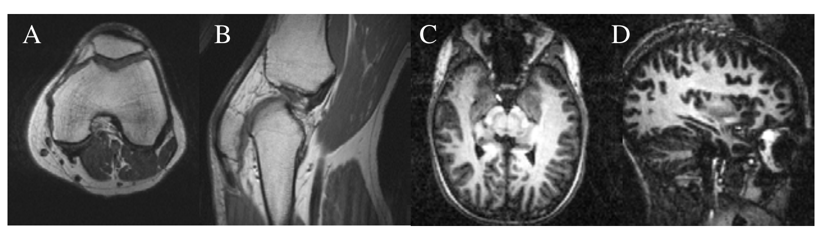


Figure 3 A),B) Leg TEM spin-echo images; C),D) Head TEM gradient-echo images



Conclusion: We have developed leg and head split TEM coils. Splitting the shield in two pieces does not degrade the coil performance in comparison to "one piece" coils of the same size. For the leg, splitting the coil, thereby allowing the diameter to be reduced, improved sensitivity as well as patient comfort and accessibility.

References: 1) Peterson DM et al, MRM 1999;42:215-221. 2) Vaughan JT et al, MRM 1994;32:206-218. 3) Vaughan JT et al, 2004, US Patent 6,788,056 B2. 4) Vaughan JT et al, Trans. Antenna and Propagation Society International Symposium 2001;1:378-381. 5) Avdievich NI et al, MRM 2003;50:13-18. 6) Pan JW et al, MRM 1998;40:363-369.