

## A 7-Tesla High Density Transmit with 28-Channel Receive-Only Array Knee Coil

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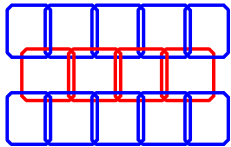
**Introduction:** As more advanced 7T MRI technology continues to emerge, the development of a wider anatomical range of RF coils has become a greater priority. When considering the orthopedic application of knee imaging, the gains from 1.5T to 3T of greater spatial resolution and higher SNR further improve at 7T, which brings further clinical detail and functional imaging to the critical knee structures of the menisci, cruciate ligaments, and articular cartilage [1]. In earlier work at 3T, a local transmit and high-channel receive coil was developed with multiple rows of elements in the S-I direction to allow higher parallel imaging acceleration factors, which reduce scan time and pulsation flow artifacts [2]. These concepts were used as the basis to develop a transmit and 28-channel receive knee coil at 7T. However, 7T presents unique challenges for RF coil design due to the shorter wavelength within the human body. Therefore, several novel design strategies including partial transmitter shielding and ultra-compact preamplifier were utilized.

**Methods:** The transmit and 28-channel receive knee array coil consists of anterior and posterior halves each consisting of fourteen rectangular receive elements. The receive elements on each half are overlapped in a continuous array with overlaps optimized to minimize coupling between neighboring elements. Each receive element is approximately 6cm on each side with 4 break points for capacitors. The element layout is given in the schematic representation (Fig. 1), and consists of three rows in the S-I direction such that the knee anatomy is centered on the middle row. This configuration provides improved SNR at the center by moving the element overlap area away from the center [2].

The transmitter coil is a 12-rung, 4-port driven, circular polarized, partially-shielded birdcage. To limit the impact of the leakage field and to minimize the radiation loss of the coil at 7T, a partial shielding concept was developed. Rather than placing a cylindrically continuous floating shield between the birdcage and the environment, the floating shield was localized to the birdcage rungs and endrings (Fig. 3). The shield was placed 1.5cm away from the birdcage structure. FDTD was used to compare the birdcage configuration with no shielding, a fully continuous shield and the partial shield concept.

Limited available space presents technical challenges in engineering a knee coil with a local 12-rung birdcage transmitter together with its corresponding partial shield and a high number of receive channels. Within the limited space constrained by the patient table and the requirement to provide patient comfort, the coil wall thickness to house all the necessary electronics and components is constrained to be about 5cm. One method to overcome these constraints is the use of ultra-compact, low noise, pre-amplifiers (Fig 4), which are even smaller than what was used in previous work [3].

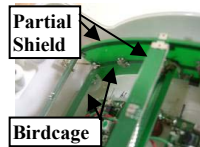
The Siemens MAGNETOM 7T system at the University of Pittsburgh was used for testing obtaining images using a healthy volunteer.



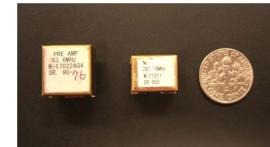
**Figure 1:** One-half of receive element layout (same for both anterior and posterior halves).



**Figure 2:** Exterior Coil Photo

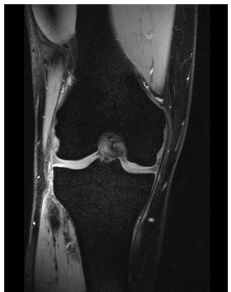


**Figure 3:** Partial Birdcage Shielding Layout



**Figure 4:** Relative sizes of miniature pre-amplifier, ultra-compact 7T preamplifier, and U.S. dime.

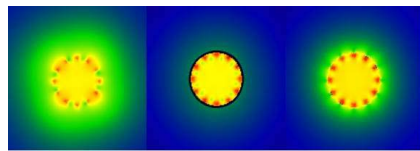
**Results:** Healthy volunteer was scanned with 7T 28-channel array (Fig 5). Comparing birdcage shielding configurations, the shielding coefficient, defined as electric field per  $\mu\text{T}$ , for a birdcage without any shield shows a result of 39.9V/m per  $\mu\text{T}$  while a fully shielded birdcage results in 14.7V/m per  $\mu\text{T}$ . The partial shielded birdcage result is 20.8V/m per  $\mu\text{T}$  (Figs 6 and 7).



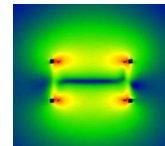
**Figure 5:** Coronal MR Image of healthy volunteer.

**Scan Parameters:**

Sequence: gre	Slice Thickness: 3mm
TE: 4.59ms	TR: 170ms
Acquisition Time: 43.52sec	Voxel size: 0.5 x 0.5 x 3mm
Resolution: 256x512	# of Averages: 2



**Figure 6:** B<sub>1</sub> of unloaded birdcage with no shield, full shield, and partial shield (arbitrary units)



**Figure 7:** Eyz of unloaded partially shielded birdcage (arbitrary units).

**No Shield:** 39.9 V/m per  $\mu\text{T}$   
**Full Shield:** 14.7 V/m per  $\mu\text{T}$   
**Partial Shield:** 20.8 V/m per  $\mu\text{T}$

**Conclusion:** The partial shielding used for the birdcage transmitter shows a significant shielding coefficient improvement over the non-shielded case and only a small drop in the shielding coefficient compared to the fully shielded configuration. The ultra-compact pre-amplifier developed at 7T has a smaller physical size and similar performance to a previously developed miniature pre-amplifier used commercially at 1.5T and 3T. These and other design strategies allowed for the successful development of a 28-channel knee array coil at 7T. Future work will involve expanding the single-channel birdcage transmitter into a multi-channel transmitter array and optimization of sequences at 7T.

**References:**

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- [2] M. Finnerty, et al., "A 3D Parallel Imaging Capable Transmit and 15-Channel Receive Array Knee Coil at 3T," in Proc. Intl. Soc. Mag. Reson. Med. 16, 1077 (2008).
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**Acknowledgements:**

This work was in part supported by the National Institutes of Health and National Institute of Biomedical Imaging and Bioengineering, Grant Award 2R44EB007094-2.

Note: The concepts and information presented in this paper are based on research and are not commercially available.