Reimagining Flexible Coil Technology

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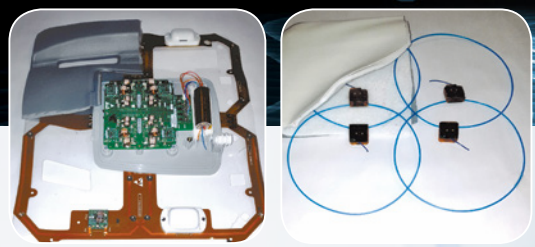

Figure 1. Conventional coil technology (top) compared to AIR Technology™ (bottom). AIR Technology™ replaces seven components weighing 175 grams per channel in conventional coil technology—acid etched circuit board loop; loop capacitor nodes: matching circuit; input-balun; decoupling resonator/switch; preamplifier; and output balun—with two components weighing 45 grams per channel.

Across the MR industry, there has been a concerted effort to develop comfortable coils that are more flexible and conform to a variety of patient sizes. Current coil designs that include copper etching, loops of conductive wire (and the techniques employed to keep the loop isolated), interfacing electronics, and components to manage the high stress transmit field and isolate the patient, result in coils that are large, bulky, heavy and rigid. These coils can be uncomfortable for the patient and may also be difficult for the technologist to lift, move, and position.

In 2011, GE Healthcare introduced the Geometry Enabled Method (GEM) Suite of coils. The GEM Flex Coils were crafted to embrace the unique body habitus of each patient by adapting size and shape for a closer fit to the desired anatomy. The flexible arrays provided higher overall image quality, using 16-channel phased array designs with dense element topologies, all while improving patient comfort and technologist workflow. The GEM concept was a first step in the progression of redesigning and reimagining coil technology.

At RSNA 2016, GE Healthcare continued the evolution of coil technology with the unveiling of the AIR Technology™ Suite, a new concept in coil design. AIR Technology™ Coils were developed to address several clinical needs: clinical coverage with high SNR, optimized geometries for maximum (use of) parallel imaging, an adaptive design that fits 99.9% of patients and ultra-lightweight.

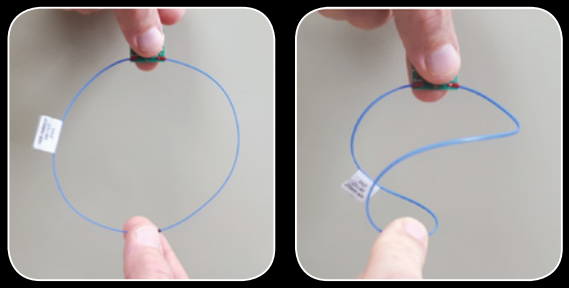

Figure 2. The AIR Technology™ Coil uses special conductor material designed for ultra-flexibility, while maintaining its electromechanical properties.

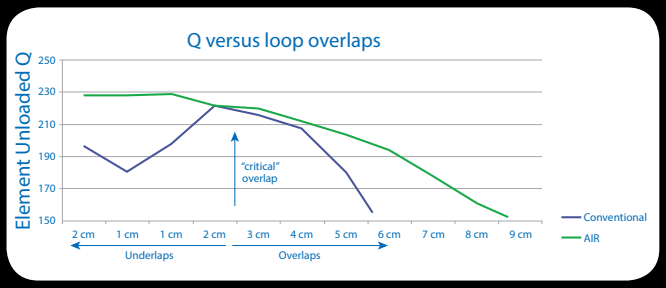

Figure 3. With AIR Technology™, the "critical" overlap is less of a design constraint.

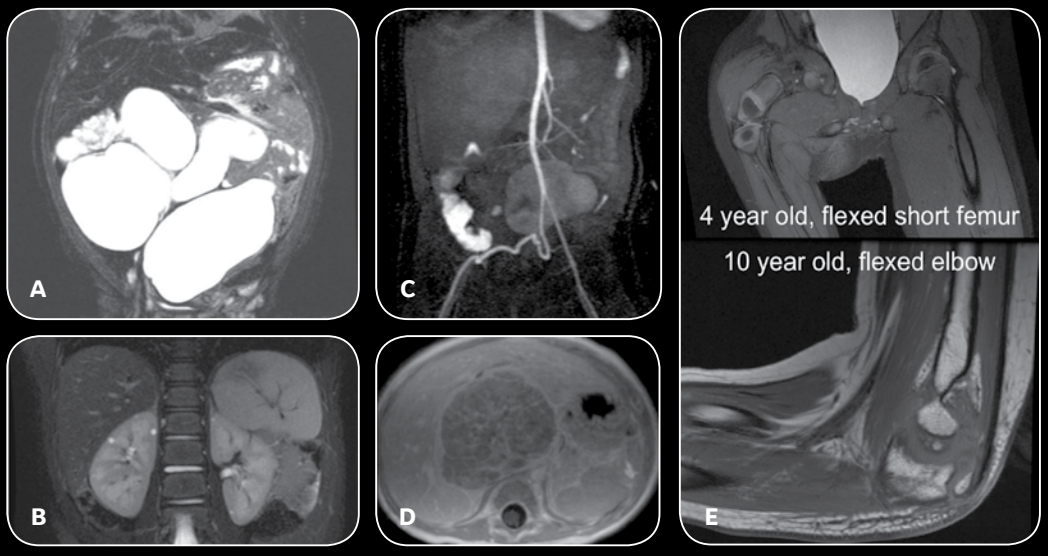

Figure 4. A series of pediatric cases were evaluated using an AIR Technology™ Coil. The AIR Technology™ Coil is designed to adapt and conform around the anatomy, even in cases of (A-D) severe abdominal pathological findings and (E) extreme musculoskeletal deformations.

Images courtesy of Dr. Shreyas Vasanawala, Stanford University, Department of Radiology.

While GEM Flex Coils are routinely employed in clinical settings, there were design challenges in interfacing the flexible board to loop components, which can lead to high stresses in those regions. GE Healthcare scientists, engineers, and researchers addressed this issue by replacing the printed wiring boards and discrete components with a newly developed multiple resonator conductor arrangement that eliminates lumped components and circuit boards. This exceptionally durable and flexible loop, named the INCA conductor, also reduces electric field coupling to the body and other loops.

AIR Technology™ also incorporates proprietary E-Mode electronics that are designed to reduce component volume by more than 60%, reduce coupling flex conductor geometries by 30%, and deliver 95% more transparency for MR attenuation correction. This technology is also designed to reduce current noise, boost linearity, and improve tolerance to varying coil loading conditions. The E-Mode electronics consist of a matching circuit, input balun, decoupling resonator/switch, preamplifier, and an output balun. Forty-five grams is the calculated weight per element/loop for the AIR Technology™. The combination of the INCA conductor with the E-mode electronics produces a single AIR Technology™ element, which is functionally independent and electrically immune to its surrounding environment or other neighboring AIR Technology™ elements. As a result, the technology is adaptable to work well in low- to high-density coil applications.

Additionally, this design can support different loop sizes. The new loop design was then packaged in lightweight performance textiles utilized in aerospace, firefighter protective clothing, and racecar driver suits to provide biocompatibility and flame retardant features.

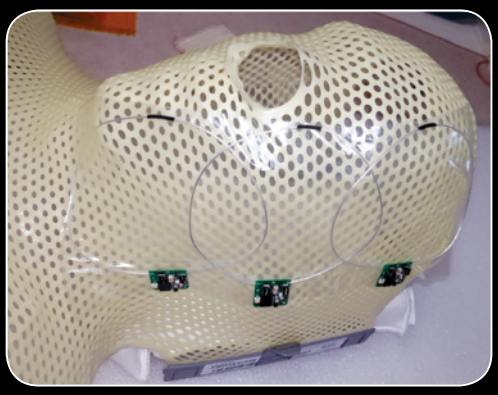

Figure 5. The flexible, compact, and load/shape tolerant design of AIR Technology™ may enable its use in many different designs.

Figure 6. Initial images of a heart and hip using AIR Technology™ on volunteers.

The goal is total freedom in coil positioning and handling, exceptional patient comfort—66% lighter weight—and 80% more flexible design opportunities. There is potential to use AIR Technology™ Coils on neonates since they are lightweight and flexible enough to conform to the body for excellent SNR and acceleration (parallel imaging). By eliminating copper waste and utilizing renewable/sustainable processes to reduce typical electronics and packaging waste, the AIR Technology™ Coils are also 90% "greener" and consume 50% less power for lower operating costs, in relation to conventional coils.

Based on the AIR Technology™, GE Healthcare is unveiling a suite of new coils. In addition to the 48-channel Head Coil designed to fit 99.9% of the patient population, GE Healthcare plans to introduce a 30-channel anterior array providing 65cm of coverage and a 60-channel posterior array providing over 110cm of coverage. This new suite of coils would combine the highest channel count density coil coverage for head to thigh multi-station imaging (141 total channels or 1 channel per 1cm of z-coverage) with an exceptionally adaptable, conforming, and ultra-lightweight design. Further, the exceptional isolation between elements allows designers to shift to a new paradigm where the overlap between elements can be maximized without degrading performance across elements. This allows for a higher density of coil elements than would be practical in a traditional design.

GE is committed to leveraging the AIR Technology™ to develop new high performance, lightweight coil designs across the spectrum of GE products. Further, the development of AIR Technology™ may also enable continued innovations in coil design including: wearable, stretchable coils, modular coils, lower cost disposable paper coils, and coils that can be used in radiation oncology and/or surgery settings and applications.