Quality Control of RF Coils

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A Radiofrequency (RF) coil is an essential component of the NMR/MRI scanner, typically made by a series (parallel) lumped parameters resonant circuit, whose function is to transmit the RF pulses (90°/180°) necessary to provide spin transitions and to receive the NMR signal (FID/Echo) by the induction principle. The RF coil needs to be tuned to the Larmor frequency of interest, which depends on the nuclei under study and the intensity of the static B_0 field. RF coils can be designed as a single surface coil, single volume coil and/or as an array of multiple coils. Typical resonant frequencies range from the kHz to the GHz range, depending on the B_0 field, sample size and applications. Multiple-tuned RF coils suitable for simultaneous detection of the NMR signal of two or more nuclei are also available.
In this lecture, after a general introduction on the current RF coils used in clinical and preclinical applications, we will focus on quality controls (QC) of RF coils. First, we review the workbench methods necessary to perform QC of RF coils: vector network analyser (VNA); scattering parameter matrix (S11; S22; S12; S21); Smith chart and impedance; pick-up coils; 50 ohm loads; perturbing methods for assessing the resonant modes. Then we present a practical example of workbench measurement with a standard RF surface coil and a volume birdcage RF coil (S11; resonant frequency f0; coupling and delivered power; bandwidth BW; unloaded and loaded quality factor Q; RF efficiency B1/SPQRT(Power); effects of loading phantoms; RF spatial distribution; quadrature isolation S12). Finally, we will focus on the selection and use of test objects for QC of RF coils (size, shape, filling solutions) and on MRI methods for characterizing RF coils (wobble; flip angle calibration; B1 field mapping; quadrature isolation).