Title: **Innovations in UHF-MR Technology/Methodology: An Update.**

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Specialty area: Educational session: Cardiac MR Today & Tomorrow.
Target Audience: Scientists and physicians with an interest in cardiovascular MR
Objective: Understand the RF challenges of 7T cardiac MRI and resultant innovations in UHF RF technology

Purpose.

The greatest, technical challenge of 7T cardiac imaging is undoubtedly obtaining sufficient control over the Radiofrequency (RF) field. The short wavelength in tissue at 7T leads to destructive B_1^+ interferences causing signal voids as well as increased levels of RF tissue heating. In this work we will touch upon the RF challenges for 7T cardiac imaging and present the latest innovations in RF technology.

Discussion

Transmit arrays are essential for 7T cardiac imaging. By phase/amplitude modulation of the array elements, socalled B_1^+ shimming, the disturbing interferences can be mitigated. Various 7T groups have designed cardiac transmit/receive arrays consisting of stripline or loop arrays [1-3]. Recently, it has been pointed out that for deep lying organs such as the heart, a radiative transmit element has benefits with respect to RF penetration and signal-to-noise [7]. A further advantage of this approach is that B_1^+ shimming becomes more straightforward with radiative elements as the B1+ phase patterns display less rapid spatial phase fluctuations as shown by figure 1b. Over recent years 7T cardiac transmit array are equipped with an increasing number of transmit elements to improve the control over the RF field, from one element in initial studies to even32 transmit channels more recently [4.5]. In the future, it is foreseen that the number of transmit channels will continue to grow and will be combined with new RF feeding strategies such as in-bore or on-coil amplifiers [6]. While most setups have been transmit/receivers, there are some clear advantages in using separate receive coil arrays. The ability to integrate pre-amp on the coil solves coupling issues and allows for a high number of receive channels fully exploiting the augmented parallel imaging performance at high fields.

SAR management is vital for 7T cardiac imaging, which are typically run with high RF duty cycles. Local SAR monitoring is complicated by various physical aspects. The interaction of an RF field with the human body is generally very complex leading to a strong inter-patient dependence. In addition, transmit arrays not only affect B_1^+ interferences but also alter electric field interferences that govern the SAR levels. Recent work, however, has demonstrated significant progress towards patient specific ,local SAR assessment [8,9]. An important innovation is a methodology which allows for a forehand identification of body locations that are at the highest risk of being heated [10,11]. In this way, the local SAR needs only to be assessed in these socalled virtual observation points, which could distributed over various body models. This methodology strongly simplifies real-time local SAR monitoring making it even feasible to include local SAR constraints into the pTX RF pulse design [11]. Very relevant for the clinical acceptance of 7T cardiac imaging, is the safety of intra-coronary stents at high fields. The main risk arises from a possible, resonant antenna effect in which the stent absorbs RF energy in a resonant fashion leading to strong heating as the stent's dimensions approach the reduced RF wavelength at 7T. However, various experimental and simulation studies demonstrate that such a scenario is very unlikely at 7 Tesla. The resonances in the stent have an inherently, low quality factor due to high losses connected to the high RF frequency minimizing the risk for sweeping up the induced currents on the stents [12,13 More coordinated work is needed here in which intra-coronary stents are tested for 7T use in a systematic manner in simulations and experiments.

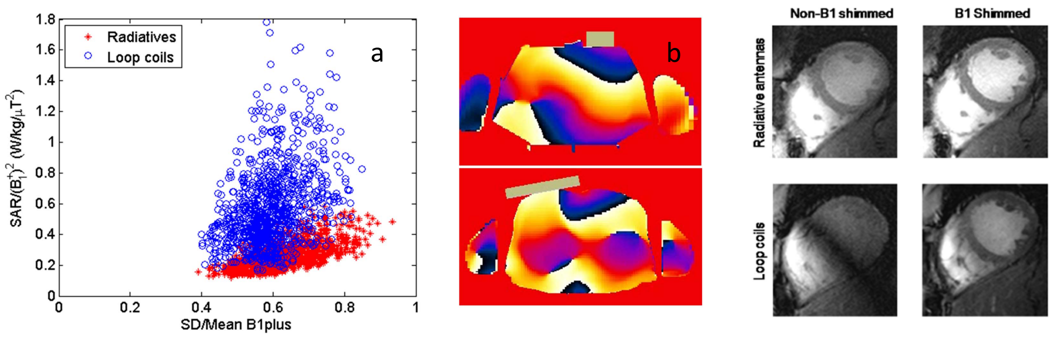

Figure 1a) Scatter plot showing shimming performance for an cardiac array of radiative elements and loop coils. Each dot represents one RF shim setting. b) Simulated B1+ phase patterns for one radiative antenna (top) and one loop coil element (bottom). c) Short axis FLASH 7T images with a 8 elements radiative array (top) and loop coil array (bottom).

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