1.5T vs 3.0T: A Technical and Application Update

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The golden age of 1,5 T MRI lasted for almost two decades. Is it over and will we have a next period of 3,0 T MRI systems? Or do we expect a diversity of magnetic field strengths in clinical applications? The market of 3 T is expanding and more and more systems are available for scientific and clinical use.
The effects of higher magnetic field strengths in magnetic resonance have been understood even long before MRI has been invented: higher signal to noise ratio (SNR), altered relaxation time constants (T_1 and T_2) and increased spectral resolution. In MRI, these are in most cases positive effects. The spatial resolution can be improved, the image contrast can be better, the measuring time could be shortened which allows more MR measurements within one study period, lower doses of MR contrast agents can be applied and a better characterization of lesions is available. The biological tissue is quite inhomogeneous in its magnetic susceptibility constants. Therefore higher field strength exhibit better "susceptibility contrast". In all situations where SNR is intrinsically poor, new measurements become available in higher magnetic fields.
However, there are adverse effects too, especially for MRI studies. Images become more and more sensitive to magnetic field inhomogeneities resulting in image distortions and shadings. The radiofrequency (RF) B_1 field becomes inhomogeneous in high magnetic fields due to a reduced RF penetration in the tissue and RF field focussing. The specific RF absorption rate increases proportional to the square of the magnetic field. Higher magnetic fields need higher gradient strengths and shorter ramp times for MRI. Both, gradients and RF power however are limited due to safety reasons. Nevertheless, better images in high magnetic fields are available for a better clinical diagnosis. Is there an optimum risk/benefit ratio?
Since MR parameters are changed, possible artefacts have to be avoided, safety problems have to be addressed and new biological information is available in higher magnetic fields, all MRI pulse sequences must be optimized. This has become very clear in all studies where 1,5 T and 3,0 T applications are compared. The presentation will summarize the most important MR pulse sequences and will show their characteristics at 3,0 T.
In order to retain the SNR increase at 3,0 T vs. 1,5 T, all parts of the MRI system have to be optimized: the coil systems and loading, electronic design and gradient hardware. It becomes more and more evident that the field of 3,0 T MRI is also a playground for all versions of parallel imaging techniques and coils having many elements (32 and more).
Advantages for clinical applications of 3,0 T have been shown for practically all organs, all parts of the body and for the clinical diagnosis of many diseases. Although the number of patients per study when comparing 1,5 T and 3,0 T and the number of studies are still low (less than 100), it is very clear now that MRI is considerably improved at 3,0 T. The present state of clinical applications will be summarized in this presentation.