# HIGH RESOLUTION BILATERAL HIP JOINT IMAGING AT 7 TESLA

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**Introduction**: High-resolution hip joint MRI becomes clinically very important since recent advances have made hip arthroscopy an efficacious approach to treat a variety of hip diseases in a young population. If left untreated, these conditions can lead to premature osteoarthritis (1). A pre-operative hip MRI is considered standard of care in these patients with femoroacetabular impingement (FAI). Yet, the most important question to guide surgical decisions regarding cartilage health versus disease cannot be assessed using current clinical MRI techniques, even if intraarticular Gadolinium is present. Because of gains in tissue contrast and spatial resolution reported at ultra high magnetic fields, there are strong expectations that imaging the hip joints at 7 Tesla will improve diagnostic accuracy. Furthermore, there is strong evidence that the majority of these hip abnormalities occur bilaterally, emphasizing the need for bilateral imaging (2). However, obtaining high quality images in the human torso, in particular of both hips simultaneously, must overcome a major challenge arising from the short radiofrequency wavelength utilized at 7 Tesla that leads to severe inhomogeneities in transmit B1 ($B_1^+$) phase and magnitude, typically resulting in areas of low signal and low contrast, and consequently impairing use for clinical applications (3).

**Methods**: Twelve healthy volunteers, who gave written informed consent, were included in this HIPAA – compliant study, which was approved by our Institutional Review Board (IRB). A 16-channel strip-line transceiver RF coil was used, together with a $B_1$ shimming algorithm aiming at maximizing $B_1^+$ magnitude in six regions of interest over the hips, which were identified on axial scout images on both, the left and the right hips. In order to improve the quality of fast multi-channel B1 maps, the following parameters were optimized: 1) higher nominal flip angle to increase SNR because B1 is fairly attenuated in tissue depth. 2) Higher spatial resolution to reduce partial voluming and T2* losses. 3) Better defined ROI shapes (exploiting higher spatial resolution and using zero-filled reconstruction) also to avoid deleterious partial voluming. 4) Orientation with readout anterior-posterior, which is less efficient time-wise but much reduced physiological artifacts thus much better maps. Transmit $B_1$ phase shim solutions were calculated for both hips simultaneously to determine a set of RF phase inputs for each transmit channel. A 3D DESS sequence was obtained before and after the $B_1$ shim procedure. Furthermore, 3D MEDIC and VIBE (with the DIXON technique) were utilized**.**

**Results**: For our B1-shimming results we consistently used 3D DESS pre- and post B1-shimming to standardize comparison. Consistently B1-Shimming improved signal within the cartilage of bilateral hips, more so on the signal-deprived side. After B1-Shimming signal was very similar in the cartilage of both hips (Fig.1).

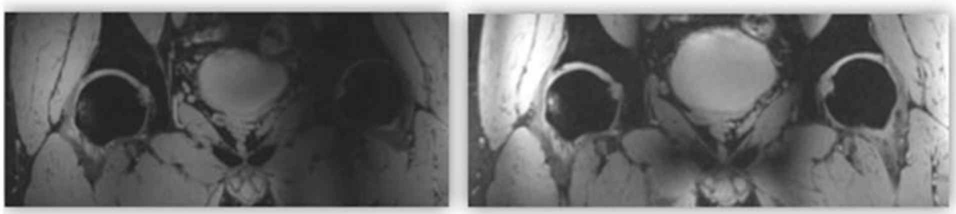

Fig.1: 3D-DESS before (left) and after (right) B1-shim), RES: 0.55 x 0.55 x 0.55 mm, TA: 12:11, TR 8 / TE 3.3

Signal in the subjacent adductor muscle, outside of the ROI's, stayed the same or dropped, as expected. Our results comparing 3D DESS before and after the algorithm demonstrate that this approach effectively addresses regions of strongly decreased signal resulting from low B1+ magnitude and thereby provides high joint tissue contrast in both hips, while reducing the required RF power. Critical to this success was a fast, small flip angle $B_1^+$ calibration scan that permitted the computation of subject specific B1 shimming solutions, a necessary step to account for large spatial variations in $B_1^+$ phase observed in different subjects. Signal to noise ratios post B1-shimming varied between volunteers. When comparing 3D DESS with 3D MEDIC and 3D VIBE within one study MEDIC (Fig.2) consistently outperformed DESS with respect to Signal to Noise ratios. Furthermore, in-phase and out-of-phase 3D-VIBE avoids the need for additional fat saturation RF pulses and reduces image blurriness. VIBE was interesting with its focus on water and fat, but overall suffered from increased artifacts. When compared with SINGLE hip imaging at 3T we achieved overall a similar resolution but imaged both hips at the same time and therefore covered 2-3 times of the FOV.

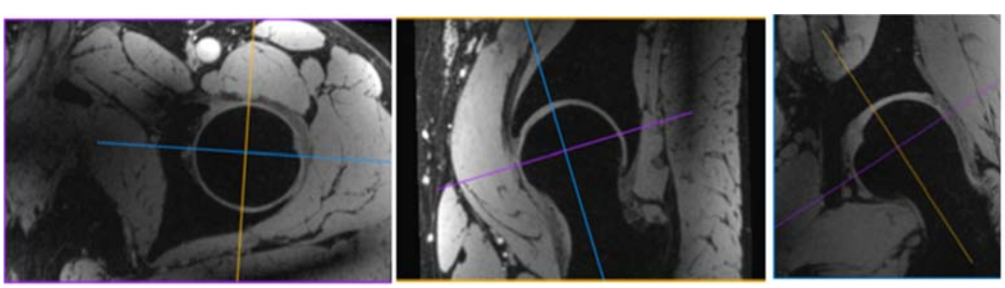

Fig.2: 3D-Medic after B1-shim depicts previously signal deprived left hip 3D MEDIC (POST), RES: 0.62 x 0.62 x 0.8 mm, FOV: 320 x 320 mm, BW: 400, TA: 11:01, TR 16 / TE 6

**Discussion and conclusion:** 7 Tesla provides highly informative images of bilateral hips using multichannel transmit RF coils in combination with efficient transmit $B_1$ shim methods. The contrast observed within the cartilage, which is not thicker than 1-2 mm, suggests that non-enhanced bilateral hip joint MRI at this ultrahigh field strength may provide the necessary contrast for diagnostic evaluation of the acetabular cartilage.

**References:** 1.Ganz et al: Clin Ortho 2003; 417:112-120, 2.Ellermann J et al: NMR Biomed. 2012;25(10):1202-8. 3.Vaughan JT et al: Magn Reson Med. 2009;61(1):244-8. **Acknowledgments** and **support: NIH P41 EB015894**