Dynamic B0 Variations in the Prostate

Catalina S. Arteaga de Castro[1], Alex Bhogal[1], Mariska P. Luttje[1], Marco van Vulpen[1], Juus Noteboom[1], Peter R. Luijten[1], Uulke A. van der Heide[2], and Dennis W.J. Klomp[1]

[1]*University Medical Center Utrecht, Utrecht, Netherlands,* [2]*Netherlands Cancer Institute, Amsterdam, Netherlands*

Introduction: ^{1}H MR spectroscopy (MRS) has a high potential for increasing specificity of diagnostics of prostate cancer. Especially at higher field strengths like 7 Tesla, the spectral resolution and the SNR can increase. This enables the detection of metabolites that overlap at lower fields like polyamines, which can be successfully detected and separated from surrounding metabolites (choline and creatine) at 7T. However, the spectral resolution also depends on susceptibility effects which occur in and around the prostate. The susceptibility changes can be patient or physiology dependent. Dynamic susceptibility variations (e.g due to breathing or heart beating) during the relatively long 3D MRSI experiments, may lead to line broadening and corruptions in the MR spectra. Estimations of the magnitude of the field distortions that can influence the spectral quality of prostate MRSI are obtained with dynamic B_0 maps at 7T while fixing the prostate with an endorectal coil balloon. We show in simulations that it is possible to correct the dynamic variations.

Methods: Four patients diagnosed with prostate cancer were examined at a 7 Tesla scanner (Philips, Cleveland, OH, USA) with a 2-elements endorectal coil[1] (ERC) tuned and matched at 298 MHz and filled with fluorinated fluid (GALDEN; Solvay Solexis, Milan, Italy), matched to the susceptibility of the prostate. In addition to our prostate protocol examinations (i.e 3D static B_0 map based shimming, T2 weighted images and MRSI (semi-LASER, TE/TR=56/2000 ms, 30x10 matrix, 5x5x5 mm^3 voxel)), additional dynamic B_0 maps were acquired for two patients (2D FFE, 2 deg flip angle, TR/TE = 10/1.97 ms, 150/300 dynamics, 1 slice, 64x48 acquisition matrix, 2.25x3x10 mm^3 voxel, 73/145 s scan time). The dynamic B_0 maps were analyzed in MATLAB (R2010b, The MathWorks, Inc.) to simulate the correction with dynamic B_0 shimming using **x, y, x^2-y^2** terms as only one transverse slice information was acquired (no z terms present). Static B_0 shimming simulations were also performed on the static B_0 maps to investigate the outcome variation depending on the static shim technique (volume, slice based and combined shim).

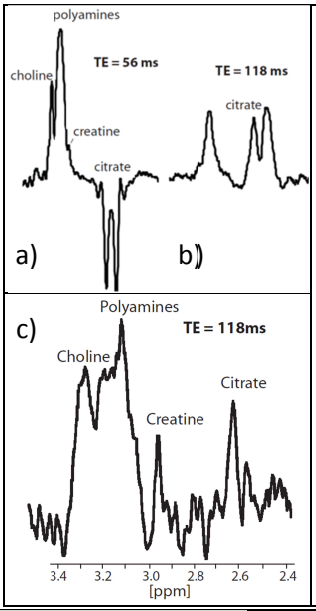

Figure 1: *In-vivo MRSI examples obtained in a 12 min acquisition using a sLASER sequence a) 56 ms TE showing distinguishable peaks from choline, polyamines, creatine and citrate, b) 118 ms TE on the same subject showing corruption of the peaks. Only citrate can be certainly distinguished. On c) an in-vivo SV example obtained in a 82s sLASER sequence acquisition on a different subject showing clear peak separation. Even at double TE it is possible to see all individual peaks when the acquisition time shortens.*

Results and discussion: While choline, polyamines, creatine and citrate resonances are well resolved in one in-vivo 3D MRSI (TE=56ms) acquired in about 12 minutes, this is clearly not the case for the 3D MRSI of about the same duration at TE=118 ms (Fig. 1 a,b). However, single voxel acquisition taken in about 1 minute at the same TE of 118 ms shows again clear resolved frequencies (Fig.1 c) suggesting dynamic field perturbations during the long 3D MRSI acquisition. Differences in spectral quality are also seen in MRSI obtained at the same TE and acquisition time, but in different subjects (Figure 2 a,b), suggesting different dynamic field variations. Analysis of the dynamic B_0 maps obtained in-vivo indeed show significant variations of up to 20 Hz (Figure 3b, green line). On two patients (Figure 3 a, b) the dynamic variation shows periodicity. On the first one the frequency is too slow to be considered breathing or heart beating. On the second case this could be the case. However, on the third example, no periodicity is seen which suggests that the variations are also caused by other physiological effects like bowel motion or gas bubbles that can get close to the prostate. Second order dynamic shim simulations (excluding **z** terms) are shown in red on figure 3. The simulations show improvements of more than 10 Hz compared to the initial variations.

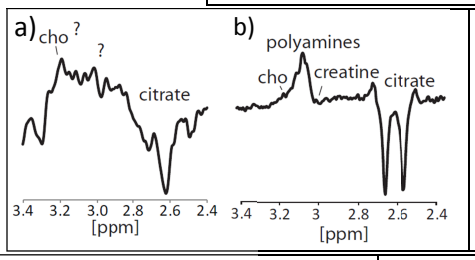

Figure 2: *In-vivo MRSI examples for two different subjects. The spectrum on a) shows a clear corruption of the spectrum, while on b) the situation shows no change in peak appearances when compared to the measurements at this TE.*

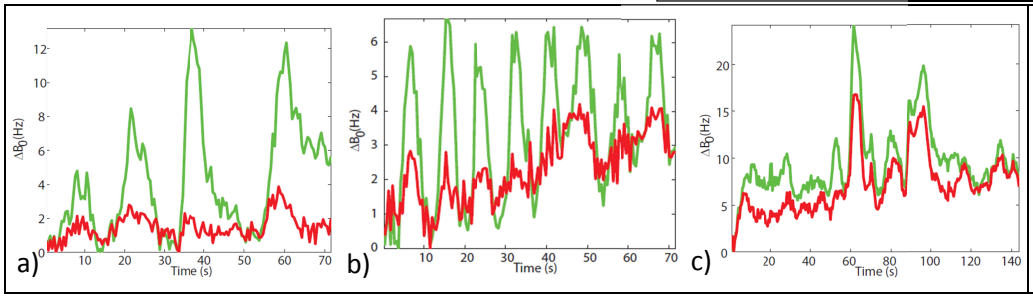

Figure 3: *B_0 fluctuations (**green**) during a), b) 73 s and c) 145 s dynamic B_0 maps acquisition. On a) and b) 150 dynamics were acquired and the variations over time seem to be periodic over 20 s and 10 s respectively. In the second case of c) there is no sign of periodicity. In **red** are the results obtained after simulating a second order dynamic shimming correction. The improvement can be as much as 10 Hz in a).*

Conclusions: Based on the good static shim results one would conclude that B_0 variations within the prostate would enable resolution of polyamines resonance from choline and creatine. However, temporal B_0 changes are observed in prostate patients of more than 10 Hz. We have shown that the temporal differences can be investigated using dynamic B_0 maps and can be substantially corrected when dynamic shim corrections would be applied. This would require navigators or field probes[2].

[1] Arteaga et al. Proc. Intl. Soc. Mag. Reson. Med. 17 (2009), p.4744
[2] van de Bank et al. Proc. Intl. Soc. Mag. Reson. Med. 19 (2011), p.646