Composite Localization with adiabatic slice selective excitation and refocusing (cLASER) for improved 1H MRSI in non uniform B1 fields

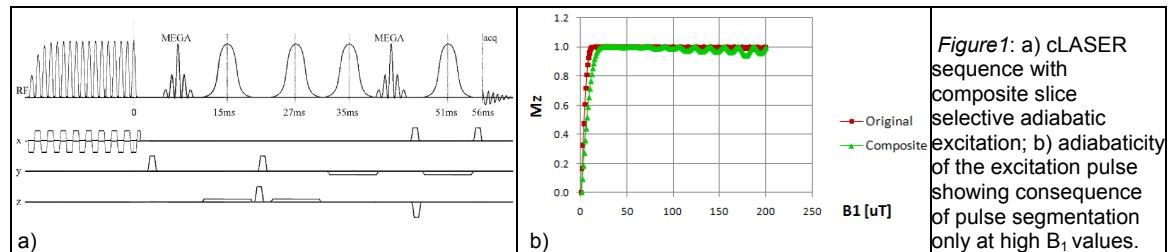C. S. Arteaga de Castro[1,2], U. A. van der Heide[1], M. van Vulpen[1], P. R. Luijten[2], and D. W. Klomp[2]
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INTRODUCTION: [1]H magnetic resonance spectroscopic imaging (MRSI) can be used as a diagnostic tool to distinguish abnormal from normal tissue by obtaining metabolic information which can be used as biomarkers. MRSI can be improved by going to higher field strengths like 7 Tesla which offer increased spectral resolution and SNR. However, at these field strengths the non uniformity of the B_1 field makes MRSI very difficult to obtain, particularly from a relatively large region of interest (ROI). Furthermore, strong chemical shift displacement artifacts occur due to the limited B_1 field. Adiabatic RF pulses for localization (i.e. LASER sequence (1)) have already shown to overcome both these limitations. However, these sequences result in high RF power deposition and have relatively long echo times (TE) because they require 6 adiabatic RF refocusing pulses for localization. Another approach is a semi adiabatic LASER (sLASER) sequence (2), which results in a much shorter TE and less RF power deposition, but is still sensitive to the B_1 non uniformities especially in combination with surface coil transceivers.
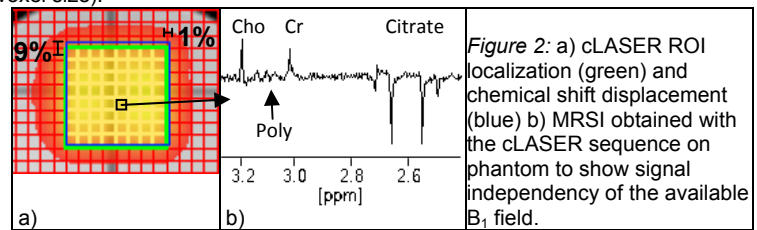
Recently it was shown that spectral-spatial (composite) pulses can be used to obtain slice selective adiabatic excitation (3). Therefore, we propose to include a composite slice selective adiabatic excitation in a sLASER sequence (cLASER) to benefit from the reduced SAR and TE while preserving the adiabaticity of the sequence. The full potential of the proposed cLASER sequence is shown with MRSI results in the human prostate in-vivo using an endorectal transceiver at 7T.

METHODS: a half passage adiabatic pulse with hyperbolic tangent/tangent amplitude and frequency envelopes was constructed in a composite way using 17 0.3 ms sinc pulses. Each sinc pulse was slice selective using bipolar gradients, resulting in an overall duration of 6.6 ms. Slice selective refocusing on the two remaining directions was achieved with two pairs of adiabatic full passage pulses. Water and fat suppression was obtained with two Mescher Garwood (MEGA) pulses as shown in figure 1a. The adiabaticity of the composite pulse is compared with the non composite hyp tanh/tan on figure 1b. The composite pulse loses its adiabaticity at higher B_1 values (~25 T) due to the pulse segmentation. A two elemen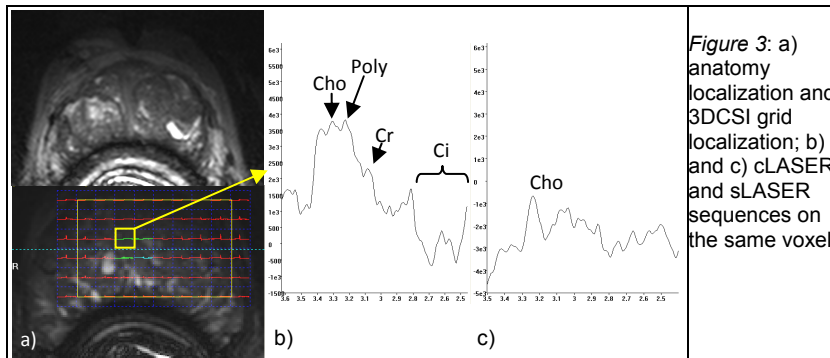ts endorectal coil (1) was used in a 7 Tesla MR scanner. Phantom measurements (3DCSI, cLASER, TE/TR=2000/56ms) were obtained to investigate ROI localization and B_1 signal dependency. In a patient with prostate cancer 3DCSI measurements with the cLASER sequence was compared to the conventional sLASER (TR/TE=2000/56ms, 6x6x10 mm voxel size).

Figure1: a) cLASER sequence with composite slice selective adiabatic excitation; b) adiabaticity of the excitation pulse showing consequence of pulse segmentation only at high B_1 values.

RESULTS: good volume selection can be obtained with the cLASER sequence with a very low chemical shift displacement artifact between choline and citrate(blue square on figure 2a) of 1% on the excitation direction (right-left) and 9% on the anterior-posterior direction. The MR spectra of the strongly coupled spins systems of polyamines and citrate (figure 2b) are not affected in any different way as with the sLASER. Figure 3a shows substantial B_1 non uniformities on the MRI with the endorectal transceiver. However, the MR spectrum in figure 3b with the cLASER has more SNR at the same location than the sLASER in figure 3c particularly in the presence of these non uniformities.

Figure 2: a) cLASER ROI localization (green) and chemical shift displacement (blue) b) MRSI obtained with the cLASER sequence on phantom to show signal independency of the available B_1 field.

CONCLUSIONS: improved volume localization is achieved by including a composite slice selective adiabatic pulse to a sLASER sequence for excitation. Due to its adiabatic nature, the cLASER sequence is insensitive to B_1 non uniformities and therefore MR spectroscopic imaging can be obtained with surface coil transceivers, even in the presence of low B_1 and non uniformities. Chemical shift displacement artifacts are kept very small with the cLASER method. The relatively short echo time of the cLASER sequence and its adiabatic nature, makes it electable for high field MRSI in combination with surface coils.

Figure 3: a) anatomy localization and 3DCSI grid localization; b) and c) cLASER and sLASER sequences on the same voxel.

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