# Improved coverage of brain tumors with 1H MRSI using Cosine Modulated Very Selective Suppression Pulses at 3T

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**INTRODUCTION:** Although 3D PRESS MRSI is able to provide excellent quality metabolic data for patients with brain tumors and has been shown to be important for defining tumor burden, the method is currently limited by how much of the anatomic lesion can be covered within a single examination. One of the major reasons for this is that the PRESS selection is rectangular, whereas the head is more elliptical in shape. Another complication is the effect of chemical misregistration between the seleceted volumes for different metabolites. While these issues may be partially addressed by using graphically prescribed outer volume suppression (OVS) pulses to conform the PRESS selected volume to the borders of the brain and avoid subcutaneous lipid, the limitations on power deposition at 3T mean that the number of such pulses that can be applied is limited [1,2]. The goal of the current study is to combine with PRESS localization with improved OVS in order to obtain larger coverage for $^1$H MR Spectroscopic Imaging ($^1$H MRSI) of the human brain. This has been achieved by integrating fixed cosine modulated, and graphically placed non-cosine modulated, very-selective suppression (VSS) pulse scheme that are optimized for high field strengths [3] and provide improved coverage for supratentorial brain tissue from various head sizes, shapes, and treated brain tumor patients.

## METHODS

The cosine modulated VSS was created from a non-linear phase SLR RF pulse [5] with a time-bandwidth of 18 designed with the phase optimized to minimize the peak RF power [6,7]. The VSS pulse had a nominal B1 of 0.116 G, a pulse width of 3.0 ms, and bandwidth of 5868 Hz. Two symmetric saturation bands were produced using a single RF pulse by modulating the RF pulse by a cosine function. The excitation with the cosine modulated pulse was optimized to generate similar suppression as a single pulse while maintaining an adequate power level. Each cosine modulated VSS pulse that was generated in real time produced two saturation bands that were spatially placed based on the desired prescription of the localization volume. The phased modulated low peak power characteristic of the cosine modulated VSS pulse allowed for 12 fixed-saturation bands in addition to the 6 graphically prescribed bands. Eight of the 12 fixed cosine modulated saturation bands were used to generate a preliminary octagonal selection region. The six additional graphically prescribed bands were used to generate an elliptical volume selectivity that uniquely conformed the selected region to the shape of the individual, as shown in Figure 1. The remaining four cosine modulated sat bands were implemented in the S/I direction. Volunteer and patient studies were performed on a GE 3T MR scanner using body coil excitation and reception with an 8 channel phased array head coil. The pulse was implemented in 3D MRSI using PRESS volume localization and CHESS pulses for water suppression in 4 minutes with TR/TE = 1100/144 ms for a single slice. These acquisitions employed spectral arrays of 16 x 16 x 1 acquired with full k-space sampling with fields of view corresponding to a nominal spatial resolution of 1cc. Five brain tumor patients were scanned and the same conventional MRSI sequence was compared to the optimized cosine modulated VSS pulse scheme.

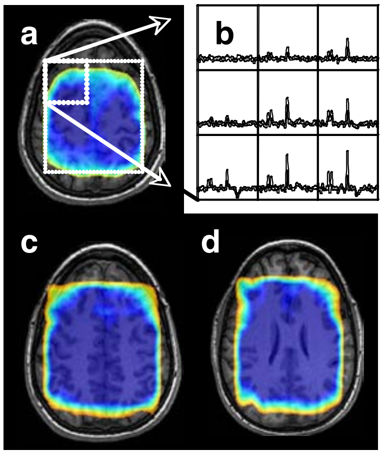

***Figure 1:*** *(a,b,d) Normal volunteer with cosine modulated PRESS MRSI, overlay of NAA peaks, (b) spectral array from superior slice selection in (a). Note lipid is within PRESS selection but adequately suppressed.*

## RESULTS and DISCUSSION

<u>*Volunteer data:*</u> Maximum coverage was achieved using the cosine modulated VSS pulse scheme in the PRESS MRSI acquisition. Figure 1 shows the high spatial selectivity of the saturation bands with a mean selection volume of 102.8 cc. Conventional selection volume of volunteer scans was 67.5 cc allowing a 1.5 increase in selection volume. The efficiency of saturation of water from the VSS pulse was 90%. The selection as conformed to an octagon shaped selection region as shown by a NAA map overlay in a volunteer in Figure 2.

<u>*Patient data:*</u> Twenty-eight patient scans were retrospectively investigated for tumor coverage with PRESS $^1$H MRSI, which used a conventional VSS pulse scheme. The mean coverage by MRSI per slice of brain tissue was 55 cc, with 63% mean coverage of the region of T2 hyperintensity. Coverage was improved by a factor of 2.5 in patients using the new OVS scheme, with the mean volume of brain tissue covered in patients being 133.3 cc per MRSI slice. Figure 2 shows a comparison of the PRESS MRSI selected volume using both methods. Figure 2c is the FLAIR image of a patient with a brain tumor, with superimposed selection regions (cosine modulated VSS and conventional). Figure 2e is a spectrum that is characteristic of tumor that was not included within the conventional OVS scheme.

## CONCLUSION

This study demonstrated improved coverage of the PRESS region prescribed by using improved outer volume suppression pulses for maximum lipid suppression in volunteers and patients by employing cosine modulated VSS pulses. Tumor coverage was improved. This is likely to be particularly important for using MRSI in planning focal therapy and evaluating treatment response.

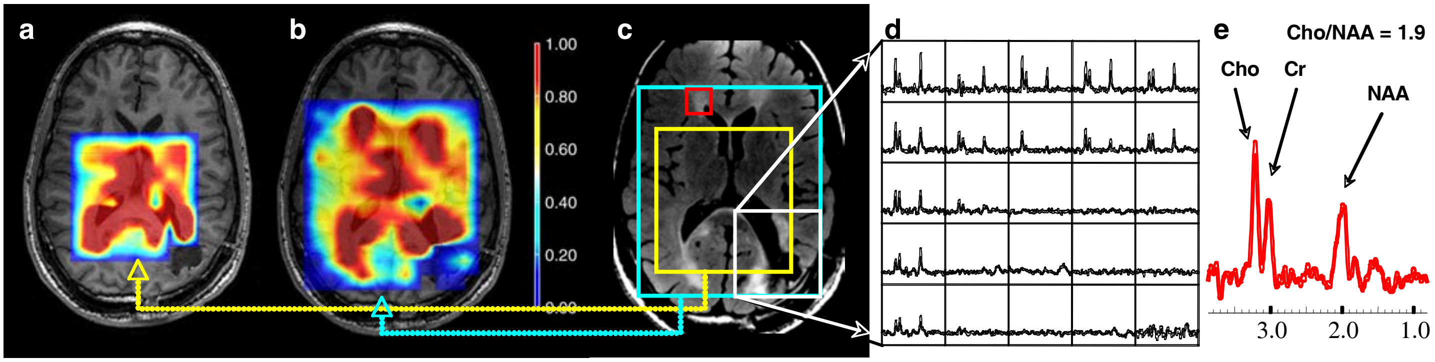

***Figure 2:*** *Brain tumor patient with $^1$H MRSI using both cosine modulated VSS pulse scheme and conventional. (a) T1 with Cho-to-NAA overlay from conventional MRSI selection, (b) and from MRSI using cosine modulated VSS scheme. (c) FLAIR image with selected regions from (a) and (b). (d) Example array of spectra shown from selection within (b) cosine modulated VSS scheme. (e) Spectrum characteristic of tumor from voxel outside of conventional coverage.*

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