TIME-VARIABLE FILTERING OF SPIRAL ACQUISITIONS FOR OUTER VOLUME SUPPRESSION

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Objective
While restricting the field of view (FOV) in MRI with Cartesian readouts is straightforward using anti-aliasing filter, slab selective excitation, and aliasing suppression techniques; that is not the case with time varying readout gradients (G(t)). Aliasing patterns are particularly difficult to identify with a spiral k-space trajectory as compared to Cartesian readout (1). We reduce aliased signal by retrospectively applying an anti-aliasing filter to the raw data (length = N samples). During a spiral readout the net gradient field rotates about the origin with increasing amplitude. Band-pass filtering the signal spectrum can define a restricted FOV (rFOV) and suppress signal originating beyond it.

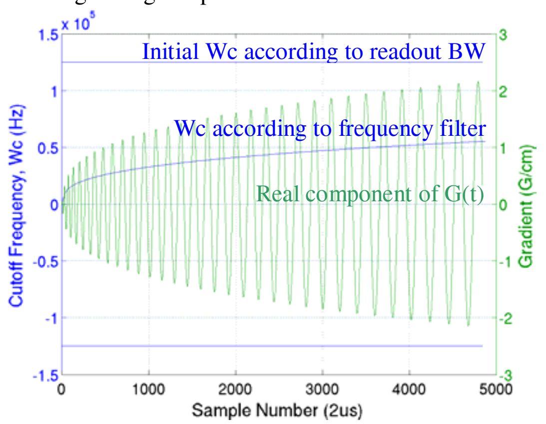

Figure 1 Cutoff frequency and gradient waveforms over a spiral readout.

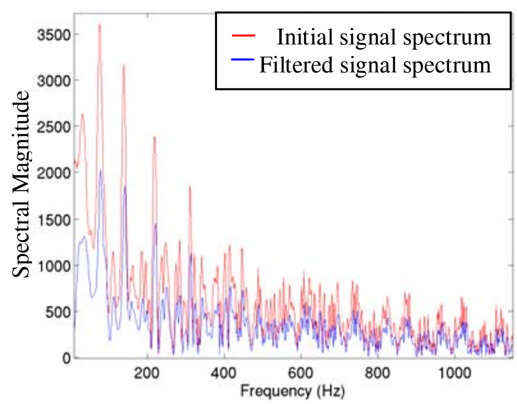

Figure 2 Initial and filtered spectra.

Methods
We Fourier transform an increasing extent of the raw data time-series (n = 1…N), and filter the resulting spectrum with the corresponding cutoff frequency (Wc(t)) (Figure 1). Wc(t) was determined according to

$$Wc(t) = \gamma\,|G(t)|\,rFOV$$

where gamma is the gyromagnetic ratio. The n^{th} sample in the filtered spectrum was thereby calculated (Fig. 2). The highest frequency in the filtered spectrum is calculated by filtering the spectrum of the entire initial time-series. The inverse transform of the filtered spectrum was calculated for the new time-series.

Results

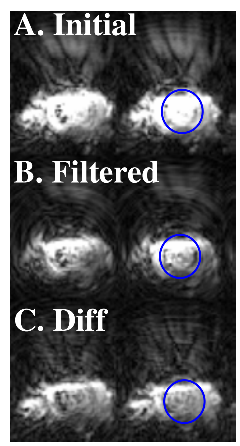

Figure 3 Demonstration of frequency filtering on T2*-weighted slices (two/row) of a fetal brain. Rows are A.) inital data, B.) filtered slices, and C.) data removed by filtering, so that C=A-B. The filter was set to supress data outside of a 10 cm circular rFOV around the fetal brain (blue circle). B. shows the resulting images. C demonstrates that the correction preferentially removes signal outside of the rFOV. In order to clearly demonstrate the filtering effect outside the desired region, we did not restrict the FOV. Features in the fetal brain such as the eye sockets are increasingly visible in the filtered images.

Discussion
Outside the rFOV signal is removed but not completely eliminated, and within the rFOV desired signal is attenuated. For this method to be implemented, original data must be acquired with a bandwidth (BW) at or above the temporal Nyquist frequency of the signal. Otherwise temporal aliasing will preclude successful filtering of the signal. That depends on the maximum gradient amplitude and the extent of the subject. However, the pass-band narrows as the gradient amplitude decreases and thus the speed in k-space is reduced. The results demonstrate a partial reduction in signal originating from outside the rFOV. To the best of our knowledge this approach has not been previously proposed.

References

1. KP. Pruessmann, M Weiger, P Börnert, P Boesiger, Advances in sensitivity encoding with arbitrary k-space trajectories. MRM 46(4): 638 - 651