SINGLE POINT SEQUENCES WITH SHORTEST POSSIBLE TE – GOSPEL

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Introduction

Sequences with an ultra short TE (<200µs), like the UTE [1] or RASP / SPRITE [2-3] techniques, are able to depict tissues with short T2 times (<100µs). They can be used for a broad field of applications, e.g. bone imaging. Starting from the single-point method RASP, where minimum TE is limited by the available gradient strength, we have improved the sequence by using the shortest possible TE for every 3D k-space point. This approach, **GOSPEL** (**G**radient **O**ptimised **S**ingle **P**oint Imaging with **E**cho time **L**everaging), allows in principle an echo time $TE_{min} = 0µs$ at the k-space center and is only limited to (currently) approximately 50µs, due to limited hardware performance.

Materials & Methods

In RASP, one k-space point is acquired at the constant echo time TE after a nonselective excitation pulse while gradients have to be ramped before the RF pulse. The border of the k-space is $k_{max} = \pm\, 1\,/\,(2\gamma R)$ for a given resolution R in the image domain. With a maximum gradient-strength G_{max}, this leads to the constant echo time $TE = 1\,/\,(2\gamma\, G_{max}\, R)$, e.g. 295µs for $G_{max} = 40mT/m$ in each spatial direction.

In our approach, we use a non-constant TE on a Cartesian trajectory throughout 3D k-space. Using always the maximum gradient strength G_{max}, the echo time TE_j for every k-space point k_j is given by $TE_j = k_j\,/\,G_{max}$. In order to obtain a self-consistent gradient table, a program was written which calculates echo time and gradient performances for each k-space point k_i according to the boundary conditions. These conditions are given by the maximum available gradient-strength $G_{max,i}$ and the corresponding $TE_{min,i}$. GOSPEL was implemented and tested on a 1.5T whole body system. The minimum echo time was limited only by the smallest possible time between excitation and data sampling, which was 50µs in this case. Fig. 1 shows a GOSPEL gradient table. Though TE changes, repetition time T_R was kept constant in the range of one to five ms. For TR = 1ms and a 128^2*16 Matrix, this leads to a total measurement time of about 4.5 minutes.

Results

GOSPEL shows an improved S/N for tissue with short T2. Subtraction with a classical RASP/SPRITE image (TE>400µs) gives a good visualization of the bones. This highlights the advantage of the TE-modulated GOSPEL sequence, as S/N can be essentially raised for tissue with short T2 values. In the off-centre parts of the GOSPEL image, slight blurring artifacts appear, probably as an effect of phase development during excitation. This blurring is the subject of further studies.

Discussion/Conclusion

In conclusion, we have shown that a significant reduction of the echo time is possible in the centre of k-space, and that this approach can easily be implemented on clinical scanners where the gradient strength is limited. Despite the fact that the total measurement time is obviously longer than for other short-TE techniques such as radial 3D methods, the significantly reduced TE allows improved depiction of bones and tendons and can now be used for attenuation correction imaging in MR-PET.

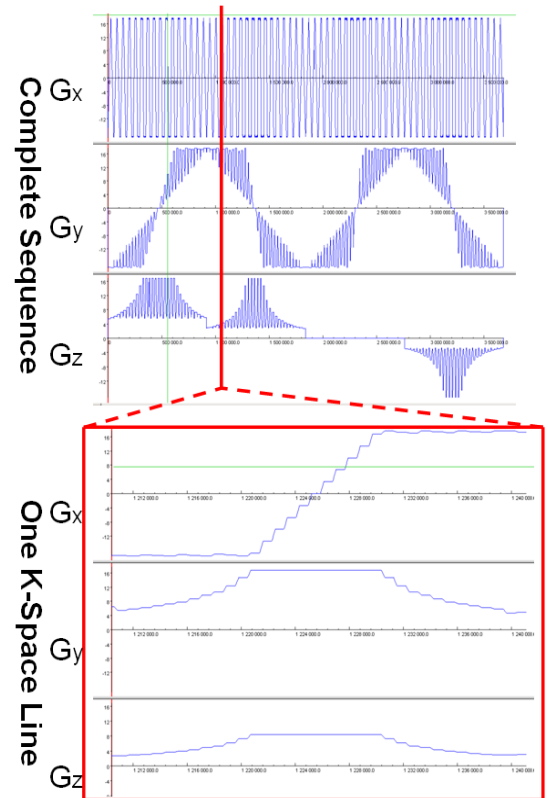## FIG.1: GOSPEL gradient table

FIG.2:

RASP/SPRITE GOSPEL Difference Image

FIG.2: Image comparison of a RASP/SPRITE image with GOSPEL image at 1.5T, FOV 150mm, 128^2*14 Matrix, $TE_{RASP}=730µs$, $TE_{min,GOSPEL}=50µs$, TR=1.5ms, $\alpha=\ 4°$, no averaging, resulting in a measurement time of 5min 45'. In vivo coronal slice (10mm thickness) of the wrist measured with a wrist-coil. The difference image clearly reveals the tendons and bones.

References:
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