# Improved Fat suppression for Coronary MR Angiography with Radial Balanced 3D SSFP through Interleaved Weighted Projection Sets

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**Introduction:** The radial acquisition is a promising method for cardiac imaging. Recent studies have demonstrated the value of the radial acquisitions in coronary MRA [1,2] with a long temporal window similar to coronary CT angiography [3,4]. However, these techniques rely on preparation pulses before each acquisition segment to provide high contrast between blood, fat, and myocardium. Cartesian acquisitions employ preparation pulses by timing the *center* of k-space to coincide with a specified regrowth time. For radial acquisitions, each projection passes through the center of k-space, thereby rendering preparation pulses less effective. Furthermore, the angular weighting of k-space can potentially cause additional artifacts. Solutions include reduced temporal windows of each data acquisition segment, and Fourier-encoding in the third spatial dimension to provide contrast weighting in kz. Song et al. have investigated the use of a k-space weighting method, KWIC [5], for creating radial fast spin echo images with strong T2 weighting. In this investigation the technique is applied to fat saturation pulses for coronary artery imaging.

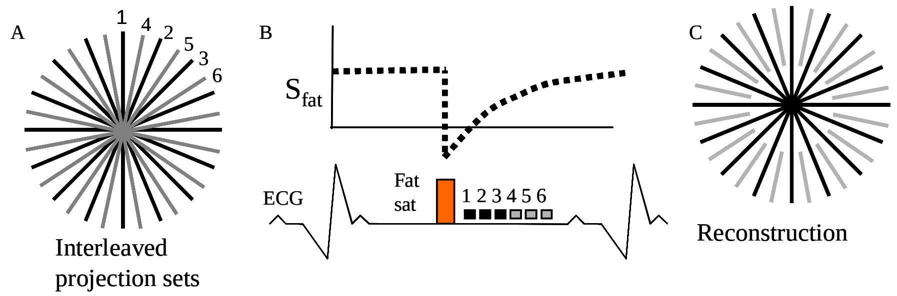


Figure 1: The projections were divided into two interleaved sets (A). The timing was such that the projections from the 1st interleaf were acquired soon after fat saturation pulse, and the 2nd interleaf was acquired later (B), resulting in greater fat signal than for the 1st interleaf (B). Reconstruction consisted of using interleaf 1 for central k-space, and both interleaves for outer k-space (C).

**Methods:** The data were separated into two interleaved projection sets as shown in Fig. 1A (grey and black). The data collection timing for the N projections collected in each heart-beat (here N=6) was modified so that in each heart beat, after the fat saturation pulse, projections from the 1st interleaf (black spokes) were acquired early in the data acquisition window (maximal fat saturation), and projections from the 2nd interleaf (grey) were collected later (Fig. 1B). This resulted in a lower fat signal for interleaf 1 compared with interleaf 2 (see Fig. 1B, showing the regrowth of the fat signal). Reconstruction is shown in Fig. 1C, where interleaf 1 alone (black) is used for central k-space data, but both projection sets are used for outer k-space data. The central k-space data was weighted by a factor of two for density correction. Imaging was performed on 3 volunteers with a Philips 1.5T Gyroscan ACS-NT (Philips Medical Systems, Best, NL). 3D SSFP, ECG-gated, segmented, navigator-gated coronary MRA was performed as previously described [6], including a fat saturation pulse before each data acquisition block. The data collection used projections for the x-y plane, and slice-encodings in z. For each slice-encoding step, all projections were acquired over a of group heart beats, before proceeding to the next slice-encoding step. All studies were performed on the right coronary artery. Scan parameters were: 360 Nr x 360 Np x 13 Nz, TR/TE/$\theta$= 4.9ms/2.4ms/120º, 1 x 1 x 3 mm, Turbo factor 36, 180 ms window.

**Results:** Figure 2 shows a slice of the right coronary artery of a patient acquired with a 180 ms temporal window, using the interleaved acquisition scheme, and reconstructed without weighting (Fig. 2A), and using the algorithm of Fig. 1C (Fig. 2B). The image in Fig. 2B depicts the coronary artery more clearly, partly due to improved fat suppression, and also potentially due to reduced SSFP artifacts from fat, since fat was suppressed.

**Conclusion:** We demonstrate that k-space data weighting applied for improvement of magnetization preparation in radial coronary artery imaging is feasible. These preliminary studies confirm that this method provides images with reduced subcutaneous and epicardial fat. The suppression of fat may also suppress SSFP artifacts due to off-resonant fat signal. Further studies are needed to characterize the tradeoff between reduced fat signal provided by the interleaved order and k-space weighting, and the potentially valuable motion properties of a non-interleaved order for coronary MRA. Furthermore comparison is necessary between this method, and reconstruction with a single interleaf (i.e a shorter temporal window).

Figure 2: (A) A single slice from a 3D coronary MRA exam, acquired with interleaving but no weighting. (B) The same data set processed with weighting as shown in Fig. 1C. Arrows point to distal RCA segments that are more clearly seen in (B). There are fewer artifacts and the anterior chest wall fat is better suppressed in (B).

**References:**

1. Larson et al. MRM 48:594 (2002). 2. Weber OM et al., ISMRM 2003 730. 3. Stehning C et al., ISMRM 2003, 732. 4. Leiner T et al., SCMR 2004, 291. 5. Song HK and Dougherty L. MRM 44:825 (2000). 6. Spuentrup E et al. Invest Rad. 2002: 37: 637-42