INTRODUCTION: Transient balanced steady-state free precession (bSSFP) is the sequence of choice in non-contrast enhanced coronary MRA at 1.5T because of its intrinsically high blood signal and blood-myocardium contrast compared to non-balanced sequences. Earlier studies of bSSFP at 3.0T report dark bands, degraded image quality, shorter visible vessel lengths, and elevated inter-observer variability compared to spoiled gradient echo sequences at 3.0T. In a recent study, localized RF and B₀ shimming provided reproducible bSSFP acquisitions for imaging the major coronary arteries in a breath-hold at 3.0T. In this work, we propose to refine the breath-hold sequence in ref. 3 with modifications that were previously proposed for acquisitions with respiratory navigators: 1) shortened RF pulses using variable-rate selective excitation (VERSE) to reduce both TR and acquisition time (Fig. 1B), 2) pre-saturation of dark band areas, and 3) improved transition to steady state.

METHODS: A 3D volume-targeted bSSFP sequence was optimized on a 3.0T MR scanner (Philips Achieva TX, Best, The Netherlands). An axial B₁+ map was acquired for localized RF shimming and a B₀ map was acquired along the 3D track of the coronary of interest to determine the localized 2nd order shim and resonance frequency. Coronary MRA acquisitions were performed using the original and the proposed sequence (Fig. 1A). Five binomial presaturation (BIPS) pulses were used to saturate the spins at frequencies where dark bands occur. The transition to steady state prior to acquisition was accelerated with a Kaiser-Bessel shaped flip angle sweep of 10 startup RF pulses. This preparation scheme has previously been reported to suppress artifacts originating from the dark band frequencies. In initial studies, the spectrally selective fat saturation (fat sat) excitation angle was optimized over the range of 80-140° for an improved fat suppression and less sensitivity to TR and field inhomogeneities. VERSE pulses (Fig. 1B) were implemented reducing the TR from 3.9ms to 3.2ms. Other parameters were: TE=1.5ms, α=50°, FOV=300×300×22mm³, voxel size=1.1×1.1×2.4mm³, acquisition window 95ms, half-Fourier factor 0.6, SENSE 2.5 in phase-encode direction. The data were acquired during 21±1 s breath-holds. Three healthy volunteers (44-52 years old) and one patient (76 years old) with coronary artery disease were scanned. Analysis was completed the scans. The experimentally optimized fat sat angle was 95°. Images of the left anterior descending artery (LAD) and the right coronary artery (RCA) are shown in Figs. 2 and 3. The BIPS pre-saturation, Kaiser-Bessel startup sweep, and shorter TR due to VERSE achieved a better suppression of artifacts as highlighted by the white arrows. The visualized vessel length and vessel sharpness compared favorably for the proposed method at 104.1mm and 51% with the conventional sequence at 92.5mm and 49%, respectively.

CONCLUSION: The refined sequence in combination with RF and B₀ shimming demonstrates image quality improvements in breath-hold bSSFP coronary MRA at 3T and warrants further investigation.