INTRODUCTION: Cine cross-sectional area measurement of coronary arteries using diastolic 3T spiral MRI has shown great potential for the quantitative measurement of early atherosclerotic endothelial dysfunction [1]. This technique critically depends on the quality of fat suppression reconstruction, this technique can be used to correct off resonance effects in the separated spiral images [3] for improved cross-sectional spiral coronary MRI.

METHODS: Cine cross-sectional spiral coronary MRI of the right coronary artery (RCA) of one volunteer was performed on a 3T clinical MR scanner (Achieva, Philips Healthcare, Best, NL). The protocol was approved by the Institutional Review Board of the hospital, and a written informed consent was obtained from the volunteer prior to the scan. The system was equipped with a 32-element cardiac phased array surface coil for signal reception and vector ECG technology [4]. Two cross-sectional slices perpendicular to the proximal RCA were acquired using a single-interleave cine spiral 2D imaging sequence (FOV=220mm; scan resolution =0.89x0.89mm²; number of spirals=17; spiral acquisition window=14ms; α=20°; slice thickness=9mm) during a breath-hold. First, a spectral-spatial excitation was used to acquire 34 cine frames with a temporal resolution of 19.3ms as a baseline scan. Next, the 3P-Dixon technique was performed by acquiring three different echoes (TE increment=0.80ms) with a spatially selective excitation over three consecutive time frames in the cardiac cycle. The reduced temporal resolution with 3P-Dixon was compensated by the use of a sliding window reconstruction to maintain the number of cine frames (36 echoes obtained using 3-point Dixon with TR=18.8ms to generate 34 cine frames) per cardiac cycle. The reconstruction process consists of water/fat separation on the echo data using an algorithm similar to ref. [2] followed by a conjugate phase reconstruction (CPR) [5] for the field map-based de-blurring of the spiral images. The entire reconstruction process was directly integrated on the scanner and no off-line post processing was necessary.

RESULTS: Cine cross-sectional coronary MRI was successfully obtained with both the baseline and 3P-Dixon technique. The breath-hold duration was 18 heart beats. Figure 1 shows two time frames from the cine sequence acquired in mid-diastole (Td=646 ms) when the heart is almost stationary and, in early diastole (Td=461 ms) when the heart is rapidly moving. Since 3P-Dixon is affected by motion that may occur during three consecutive echoes, the coronary lumen is not well delineated in early diastole (solid red and blue arrows). However, in mid-diastole (solid yellow and pink arrows) a significant improvement is observed not only when compared to the early diastolic acquisition but also relative to the baseline scan. An increased amount of off-resonance blurring is observed in slice 2 when compared to slice 1 in the baseline images (dotted blue and pink arrows). 3P-Dixon with CPR clearly was able to remove this artifact, which leads to a better delineation of the coronary cross section with significantly improved visualization of other small anatomic structures such as the aortic valve (dotted white arrows). Furthermore, on all 3P-Dixon corrected images, an improved delineation of the ventricular septum is apparent with a visually improved signal-to-noise ratio of both the blood-pool and the myocardium.

DISCUSSION: We have successfully implemented the 3P-Dixon technique in conjunction with conjugate phase reconstruction for water fat separation and off-resonance artifact correction in cross-sectional cine spiral coronary MRI. The implementation was integrated on a commercial scanner requiring no off line processing, therefore improving the ease-of-use. While the proposed 3P-Dixon technique is less effective during periods of rapid coronary motion, the sliding window conjugate phase reconstruction ensures reconstruction of well-delineated coronary contours during periods of relative quiescence of the heart. This technique comes at no extra cost in scanning time and may critically support quantitative coronary endothelial function measurements. Further improvements will be necessary and include two-point Dixon or other data consistency enforcing approaches aimed at further reducing motion sensitivity.