Imaging Proximal Coronary Arteries / Coronary Root Imaging

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Introduction

Cardiac imaging can be a challenging examination and imaging coronary arteries can be slightly more complex still. There are quite a few protocols available for imaging of these small arteries within the Siemens library, such as a breath-hold slab, or using dual gating (respiratory and ECG gating) covering the entire heart or on a targeted approach 3D. Both methods can achieve excellent results. However, they are very patient-dependent, can be time consuming and, in the case of the breath-hold 3D, results are variable due to the very long breath-hold times.

To answer the clinical questions with MRI, the majority of clinicians will typically only need to consider imaging the coronary root in cases of anomalous vessels, and rarely do we need to image the entire vasculature.

Technique

I have modified a 2D TrueFISP sequence in order to image the proximal coronary arteries with a segmented bright blood approach imaging quickly and within a few breath-holds. This can be adapted for both 1.5 and 3T, and protocol parameters are very similar.

You can start by using the TrueFISP sequence in the Siemens library.

1

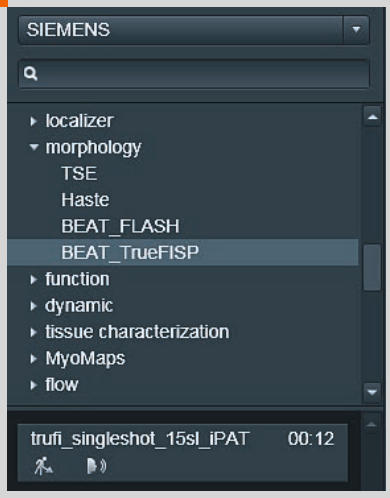


Figure 1: Heart → Morphology → BEAT_TrueFISP → **"trufi_singleshot_15sl_iPAT"**

To achieve a nice thin slice thickness in order to minimize partial voluming effects, we need to image at a minimum slice thickness of 3 mm which this sequence won't allow you to do unless we change the RF excitation pulse type from Fast → to Normal. This will disable the VERSE pulse mode and enables standard RF wave form for a better slice excitation profile, thus allowing for a thinner imaging slice.

2

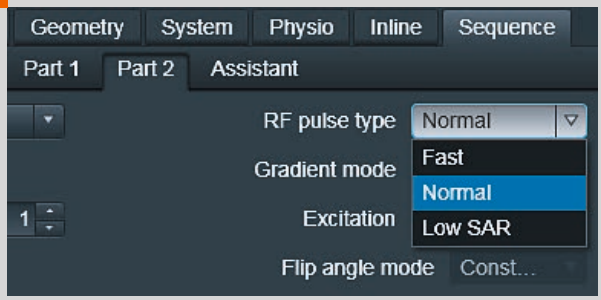


Figure 2: Sequence → Part 2 → RF Pulse type → **"Normal"**

Whilst a 3 mm slice thickness is great, we want to eliminate the slice gap, and what this sequence will allow us to do is to set a slice overlap which again helps with minimizing slice partial voluming. This can be set to **-50%** of the slice thickness where we end up with a slice thickness of 3 mm with a 1.5 mm overlap – achieving the similar results to truly acquiring the data at 1.5 mm slice thickness which is outside the possibility of this sequence. We will also need to increase the slice coverage from 25 slices to 30 or 35 slices – ensuring the coronary sinus is covered.

3

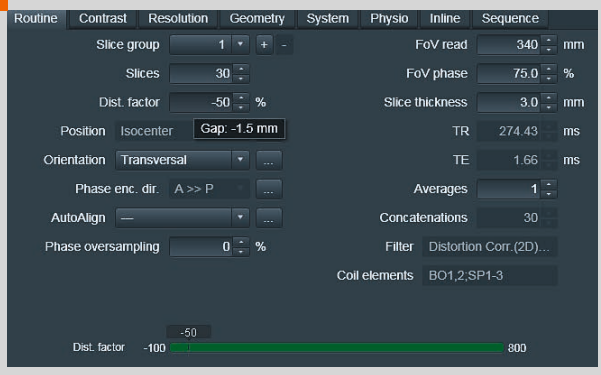


Figure 3: Eliminate the slice gap.

Another important parameter to look at is the echo spacing and ideally we must keep this below 3.4 msec. This is particularly important at 3T where an echo spacing of 3.4 or

lower will result in less dephasing artifacts. Changing the asymmetric echo from Weak → to Strong and increasing the bandwidth will enable you to reach this target echo spacing.

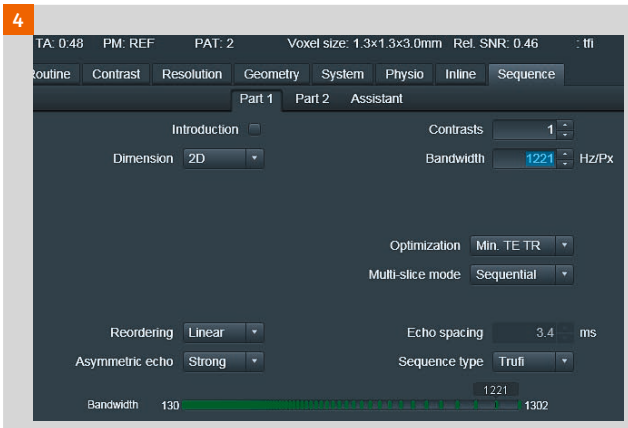


Figure 4: Sequence → Part 1 → Asymmetric echo → **"Strong"**

The next step is to ensure appropriate triggering in order to achieving motion-free images. This is done by segmentation where we need to segment/limit *k*-space data acquisitions to appropriate intervals within the cardiac cycle.

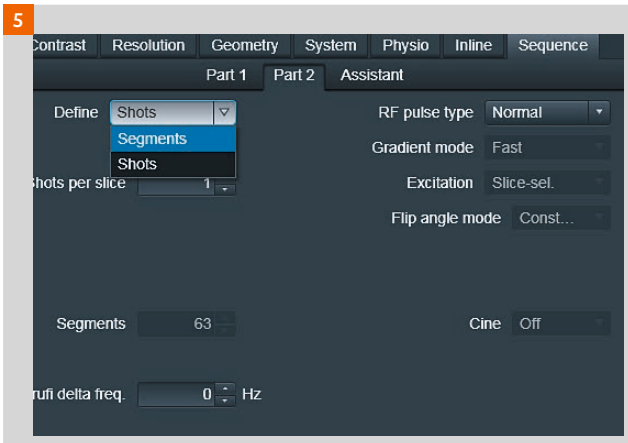
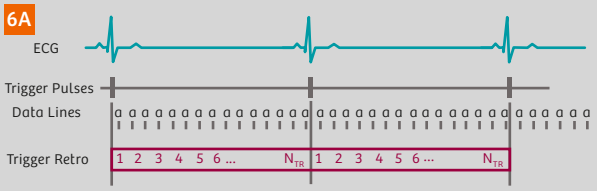


Figure 5: Sequence → Part 2 → Define → **"Segments"**

Now we need to increase the segments lines (*k*-space lines acquired in each heart beat) to roughly 30 which gives us a data readout of roughly 100 ms – suitable for most heart rates. To ensure optimal image quality, we must acquire data within the cardiac cycle when the coronary arteries are stationary. This can be done easily with the timing method – by looking at the trigger time on a 4-chamber cine image Trigger Time (TT stamp). Typically the most stable part of the cardiac cycle is in the diastolic phase; however, in fast heart rates, this may be in the systolic phase. Carefully page through the cine images, keep an eye on the right coronary sinus and take note of the trigger time when the heart stops moving in the diastolic phase and when it starts to move again at the end of the cardiac cycle – this will give us the window of opportunity to acquire data.



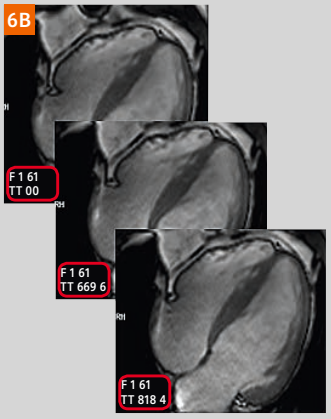


Figure 6A: Trigger Time corresponds to the time within the averaged heart beat in msec.

Figure 6B: Example: Heart stops moving in diastolic phase at "TT**669**" and starts moving again at "TT**818**" (818 - 669 = **149** msec **window**) thus we must **start acquiring after 669** msec and **finish by 818** msec.

Tip: If the heart rate has changed from the start of the examination to the point where we need to do this timing method, the timing will not reflect the patient's current heart rate and therefore you will need to re-run your 4-chamber cine view for accurate results.

Figure 7: Hovering on the Trigger delay will display detailed acquisition information: **Data window duration:** how long we acquire data for (data readout) adjusted by segments (increase segments increase window duration and vis versa) **Data window start:** time we start acquiring data which is manipulated by adjusting the Trigger Delay value. Adding the **Data window start** & **Data window duration** gives us the time we finish acquiring.

In the example above (Figs. 6A, B), we need to start acquiring after 669 msec and finish by 818 msec, and here (Fig. 7) we start at 695 msec and finish at 797 msec (102 + 695 = 797) which is excellent. If we need to start later or earlier, this is done by modifying the Trigger delay. In the case where the heart is not stationary for 102 msec (fast heart rates), we need to decrease the segments (*k*-space lines acquired in each heart beat) to reduce the Data window duration (data readout) fitting for the HR.

Now that we've taken care of the triggering and imaging slab, we must ensure we can acquire data within appropriate breath-hold times. This is done by applying breath-hold option under the Physio and PACE card which will then enable you to modify the concatenations (breath-holds). Once you have updated the concatenations, hover over the acquisition time "TA" to see the actual breath-hold times for each concatenation if appropriate for your patient.

8

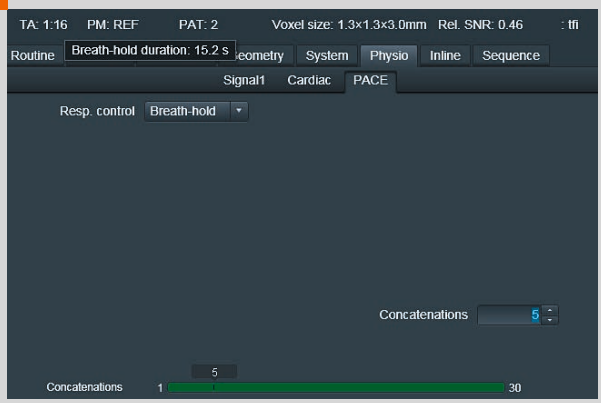


Figure 8: Physio → PACE → Resp. Control → **Breath-hold** Physio → PACE → Concatenations → **5**

Parameter name	Value	Parameter change
Slice thickness	3 mm	RF Pulse Type: Normal
Slice gap	-50%	Routine Tab
Segments	30 or appropriate for HR	Sequence Part 2 → define by segments
Breath-hold timing	15 seconds or appropriate	PACE → Breath-hold → Concatenations → 5
Echo spacing	3.4 or less	Sequence → Part 1 → asymmetric echo → Strong & possible BW increase
Flip angle	80–90 (the higher the brighter the blood)	Contrast → Flip angle

Table 1: Imaging parameters.

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Results

This modified sequence will enable you to image the coronary root with a standard 2D bright blood approach within a few breath-holds tailored for your patient's breath-hold capability and heart rate which is generally acquired faster and with higher success rates when compared to the 3D options. Since we are imaging at 3 mm with a 1.5 mm slice overlap, this data will also enable you to create some modified multiplanar reconstructions (MPR) for better visualization in the 3D card. Figures 9 and 10 are some recent examples.

9

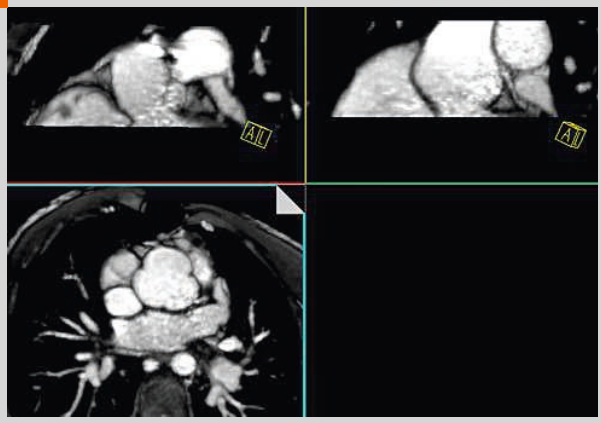

Figure 9: 7-year-old patient. *(1.5T MAGNETOM Aera. Courtesy of Lady Cilento Children's Hospital, Brisbane, Queensland, Australia)*

10

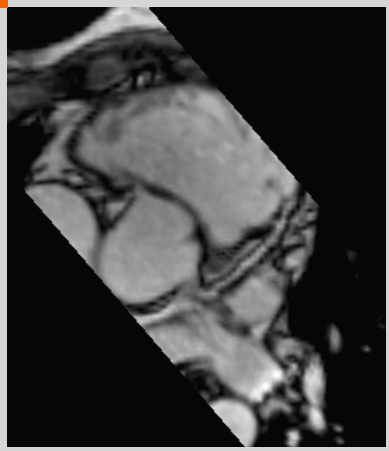

Figure 10: 34-year-old patient. *(3T MAGNETOM Prisma. Courtesy of Hunter Medical Research Institute, Newcastle, NSW, Australia)*

Conclusion

This technique is a great way to image the proximal coronary arteries using conventional imaging technique standard on any MAGNETOM system. However this technique does have its limitations shared by all normal cardiac imaging, such as consistent heart rates and reproducible breath-holds.