Highly Time-Resolved Lower Extremity MRA with TWIST, a Novel Data-Sharing 3D Gradient Echo Sequence with Spiral k-space Filling

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Purpose: TWIST (Siemens Medical Solutions) is a novel data-sharing 3D T1 gradient echo sequence developed to permit highly time-resolved MRA by spiral filling of k-space with complete sampling of a defined central region and fractional sampling of the periphery with each acquisition. The aim of this study is to compare currently used bolus-chase MRA (BC) with time-resolved TWIST MRA for the assessment of the calf arteries.

Methods: TWIST MRA and BC-MRA was performed on 8 patients (M=7, F=1, mean=59 yr, range: 17-83 yr) referred for claudication (n=5), ischemic ulcers (n=2) and for presurgical arterial mapping (n=1). All patients signed informed consent approved by the IRB. Examinations were performed at 1.5 T (Avanto, Siemens Medical Solutions) with a multichannel peripheral phased-array coil. In all examinations, a 500 mm FOV and parallel imaging (GRAPPA, r=3) were utilized.

Time-resolved TWIST MRA was performed with the following parameters: TR/TE =3.22/1.35; FA=25°; matrix size = 233x512; voxel size: 1.6 x 1.0 x 1.3 mm; full k-space acquisition time = 18.61 s, undersampled acquisition time = 6.34 s. The TWIST method divides k-space into a central region, A, which is updated for every acquisition, and B, the higher spatial frequency portion which is divided into N segments. The user can define the fraction of central k-space covered by A and the sampling density of B (1/N). Following full k-space acquisition, each subsequent time-resolved acquisition is then comprised of $AB_1, AB_2, AB_3, \ldots AB_1, AB_2, AB_3 \ldots$ For our implementation, A constituted 12% of k-space area, and sampling density B = 25%, Central region A = 12%, Sampling density B = 25%. The TWIST sequence was performed once during and 10 times following the injection of 10ml of Gd-DTPA (0.05 mmol/kg) and a 20ml normal saline flush at 2 ml/sec. Subsequently, 3 station moving table BC-MRA was performed from the diaphragm to the feet using a 3D T1 FLASH sequence with the following parameters for the third station: TR/TE =3.12/0.95, FA=25°, voxel size: 1.6 x 1.0 x 1.3 mm; TA = 13-16 sec. Imaging was performed before and after injection of 20ml of Gd-DTPA at 2ml/sec, followed by 10ml of Gd-DTPA at 1ml/sec, and 20 cc saline at 1ml/sec.

Data sets were randomized for retrospective review by two radiologists blinded to patient identity and pathology. Subtracted and MIP images only were reviewed. Overall study quality was rated for each leg on a 5 point ordinal scale (5=excellent, 4=good, 3=satisfactory, 2=poor, 1=uninterpretable). Readers evaluated 13 segments per leg (segments determined by a third radiologist). Each segment was scored for severity and length of the worst stenosis (severity: 0 = no stenosis, 1 = <50% stenosis, 2 = ≥50% stenosis, 3 = total occlusion; length: 0 = no stenosis, 1 = <1 cm, 2 = ≥1cm, 3 = total segment occlusion). Confidence was scored on a 5 point ordinal scale (1=uninterpretable, 2= uncertain diagnosis, 3=probable diagnosis, 4=highly probable diagnosis, 5=definite diagnosis).

Results: TWIST MRA (Fig 1A) and BC MRA (Fig 1B) were performed on 16 legs, for a total of 208 arterial segments. Both readers rated all 16 TWIST MRA studies as good or excellent overall image quality. Only 9 and 8 (readers 1 and 2, respectively) of 16 BC MRA studies were rated good or excellent overall quality, with motion artifact and/or venous contamination resulting in the lower ratings. Average overall image quality of BC MRA was 3.53 ± 0.88 (mean±SD), and TWIST MRA was 4.75 ± 0.44 (p = 0.0002). TWIST MRAalso provided higher levels of reader confidence in image interpretation compared to BC MRA. Mean reader confidence scores for BC MRA and TWIST MRA were 4.24 and 4.80, respectively (p=0.0006) (Table 1).

Table 1	**Mean ± SD**		**P Value**
	BC MRA	**TWIST**	
Overall Quality	3.53 ± 0.88	4.75 ± 0.44	0.0002
Confidence	4.24 ± 0.96	4.80 ± 0.55	0.0006

Table 2	**BC MRA**		**TWIST**		**P Value**
	Kappa	**95% CI**	**Kappa**	**95% CI**	
Severity	0.606	[0.52, 0.69]	0.781	[0.72, 0.84]	<0.05
Length	0.494	[0.40, 0.58]	0.732	[0.66, 0.80]	<0.05

Interobserver agreement in the evaluation of stenosis severity and length was significantly better with TWIST MRA compared to BC MRA. In the evaluation of stenosis severity, interobserver agreement was 0.606 for BC MRA and 0.781 for TWIST MRA (p<0.05). Interobserver agreement for determination of stenosis length was 0.494 for BC MRA and 0.732 for TWIST MRA (p<0.05) (Table 2).

Conclusion: In our early experience, TWIST MRA provides better overall image quality, improved inter-observer agreement in the assessment of stenosis severity and length, and improved reader confidence in image interpretation.

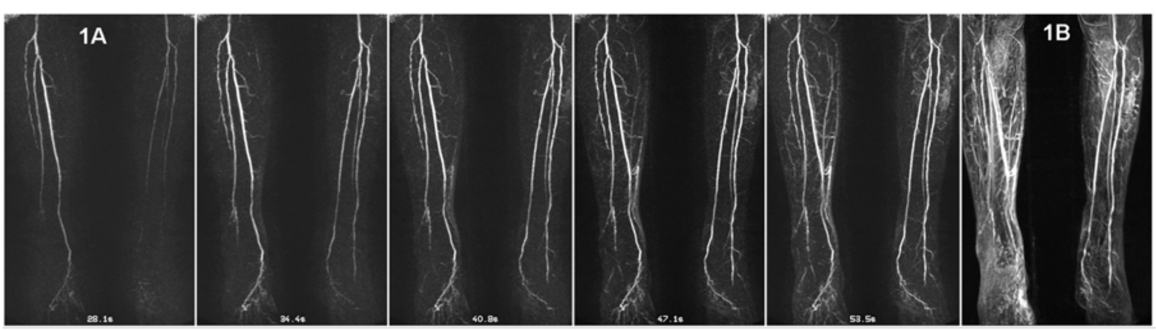

Figure 1. A) TWIST MRA, sequential 6.3 s images showing early filling of large vessels, later visualization of small vessels, soft-tissue enhancement, and venous filling, compared with **B)** BC MRA in the same patient. Images are subtracted maximum intensity projections.