

MR Angiography of Intracranial Aneurysms: 3.0T compared with 1.5T

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Introduction

The use of MR angiography (MRA) to identify and characterize intracranial aneurysms has rapidly evolved. Early clinical studies demonstrated that aneurysms smaller than 5 mm were not prospectively detected [1]. However with developments of stronger gradients and 3D time-of flight (TF) techniques, smaller aneurysms are now commonly identified [2]. Recently routine clinical imaging at 3.0T has become possible with an approximate doubling of the signal to noise ratio (S/N) compared to 1.5T. MRA is a technique that can benefit from the increased S/N by decreasing voxel size resulting in improved spatial resolution compared to 1.5T. The purpose of our study was to evaluate 3.0T 3D TF and contrast-enhanced (CE) MRA techniques and to determine if MRA at 3.0T better depicted aneurysms compared with MRA at 1.5T.

Methods

23 consecutive patients including 12 with known aneurysms and 11 suspected to have an intracranial aneurysm were imaged at 3.0T. Sequences included sagittal T1, SE and FSE T2 in the axial plane, 3D TF MRA and CE MRA using an elliptical centric view ordering [3].

The 3.0T scanning was performed on a VH/i system with an actively shielded magnet (GE Medical Systems). The system is equipped with 40 mT/m gradients with a 150 T/m/s available slew rate, and a 55 cm patient aperture. The system is equipped with a single-channel, transmit-receive birdcage head coil, and used 8.3 M4 software.

The 3D TF images were acquired with two axial slabs of 32 sections per slab, with 1.4mm-thick sections. The TR/TE was 38/3.4ms, the flip angle was 25. The field of view was 180 x 162 mm, and the prescribed matrix was 288/224. The scan time was 8 minutes.

The contrast enhanced MRA imaging protocol employed a prototype 3D-gradient echo elliptical centric view order pulse sequence. The exams were acquired with 48 sections with 1.2mm-thick axial sections. The TR/TE was 6.7/1.5ms, the flip angle was 30-40 degrees, and a relatively narrow receiver bandwidth of 150 Hz/pixel was used. The field of view was 220x154mm, and the prescribed matrix was 416x224. The scan time was 51 seconds. Depending on the slice thickness, the voxel size was 0.529 x 0.982 x 1.2mm = 0.62 cubic mm (before 3-direction zero-filling). A power injector (Spectris, MedRad, Pittsburgh, PA) injected 25mL of gadoteridol (Bracco, Milan Italy) into the right antecubital vein at a rate of 3 mL/s. Contrast bolus was followed by a 25 mL saline flush injected at 2 mL/s. Bolus timing was accomplished with the system's standard fluoroscopic software, using a 2mL gadoteridol test dose and a 20mL saline flush.

A blinded review of the 3D TF and CE MRA examinations was performed to determine the sensitivity for detection of intracranial aneurysms. The 3.0T 3D TF and CE MRA exams were evaluated for overall quality, vascular signal intensity and motion artifact. The evaluation criteria for overall quality was 5, excellent; 4, more than adequate for diagnosis; 3, adequate for diagnosis; 2, less than adequate for diagnosis; and 1, non-diagnostic. Comparison was made between the 1.5 and 3.0T MRAs using a similar evaluation method for overall image quality. In addition, the 1.5 and 3.0T 3D TF exams were directly compared and graded where 5, 3.0T far superior than 1.5T; 4, 3.0T superior than 1.5T; 3, 3.0T equivalent to 1.5T; 2, 3.0T inferior than 1.5T; and 1, 3T far inferior than 1.5T.

Results

17 aneurysms were identified in 13 patients. 17/17 aneurysms were detected with the 3.0T 3D TF MRA yielding a sensitivity of 100%. 15/17 aneurysms were detected using 3.0T CE MRA yielding a sensitivity of 88%. CE MRA failed to identify a 3-4 mm distal anterior cerebral artery aneurysm located superior to the CE MRA sequence field of view. The other aneurysm not identified on CE MRA was a left ophthalmic artery aneurysm that was obscured by contrast filling the adjacent cavernous sinus. CE MRA at 3.0T had a slightly lower image quality score (3.57±0.70) than 1.5T TF, although it was not statistically significant based on the paired t-test (p=0.17).

One patient had subtotal thrombosis of a 10mm right-sided MCA trifurcation aneurysm with high signal on T1. The aneurysm appeared

to be completely patent on the 3D TF sequence with the thrombus of similar signal to the patent 2mm remnant. Both the CE MRA and conventional angiogram confirmed subtotal thrombosis of the aneurysm with a residual 2mm neck.

Of the 23 patients imaged with CE MRA at 3.0T, 14 were initially studied with a lower resolution (voxel volume = 1.03 cubic mm) protocol, and 9 with the higher resolution protocol given in Methods. The direct comparison found that the exams with the higher spatial resolution were rated superior to the exams with the lower spatial resolution (3.94±0.73 versus 3.25±0.55, p=0.02).

Nine patients with previous 3D TF 1.5T MRA were evaluated to compare image quality between 1.5T and 3.0T. The overall quality of the 3.0T 3D TF MRAs was graded very highly. In 5 of these 9 patients the 3.0T MRA exam was far superior (n=2) or superior (n=3) than the 1.5 exam. The evaluation found that images obtained at 3.0T had a higher mean score (4.78±0.67) than at 1.5T (3.89±0.60) with a paired t-test of p=0.002.

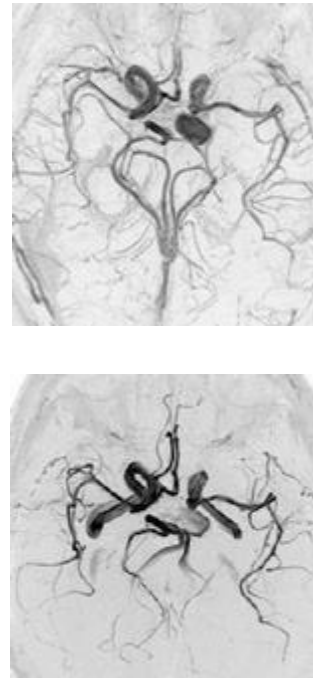


Figure 1. Axial collapse MIP images of the 3.0T CE MRA (above) and 3.0T 3D TF (below). The slow flow within the aneurysm results in incomplete visualization on the 3D TF study. The CE MRA better depicts the lumen of the aneurysm, as well as its margins.

Discussion

MRA at 3.0T offers superior image quality compared with 1.5T. CE MRA has a lower sensitivity for detecting aneurysms but may play a role in characterization of intracranial aneurysms. CE MRA is more sensitive to slow flow, better demonstrates small vessels arising from or distal to aneurysms and does not display thrombus with signal intensity similar to patent vessels. With further technical improvements such as improved coils, the spatial resolution of both 3D TF and CE MRA will likely improve at 3.0T.

References

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