Comparing the Limits of Contrast Enhanced MRA at 1.5 and 3T

O. AL-KWIFI[1], R. I. Farb[2], J. A. Stainsby[1], G. A. Wright[1]

[1]Sunnybrook & Women's College Health Sciences Centre, Toronto, Ontario, Canada, [2]Dept. of Medical Imaging, Toronto Western Hospital, University of Toronto, Toronto, Ontario, Canada

.

Introduction: Advantages of 3T could open new avenues for many clinical applications especially for MR angiography (MRA), where increasing spatial resolution remains a critical issue for improved assessment of various vascular diseases. Prior reports have demonstrated the importance of doubling the signal-to-noise ratio (SNR) at 3T [1,2]. In addition, improved contrast may be achieved as a result of different tissue relaxation times, where longer T1 values at 3T improve background suppression. In this study, the SNR behavior at 1.5 and 3T using 3D CE MRA with different spatial resolutions has been investigated to illustrate the limitation of both field strengths in producing sufficient SNR for diagnosis in intracranial arteries. In addition, the role of an 8-channel coil, with and without parallel imaging, in improving the limited SNR and/or reducing scan times at high resolutions at 1.5T is evaluated.

Method: The 1.5T exams were performed on a GE Signa (TwinSpeed or EchoSpeed, Milwaukee, WI), and the 3T exams were obtained on GE Signa (VH/i, Milwaukee, WI). Both scanners are provided with a standard head coil. The study was divided into four cases: **1) low resolution, single coil:** using a 3D CE MRA clinical protocol at 1.5T with the following parameters: TR/TE 6.2-7.4/1.7ms, 30°, FOV 22cm, phase FOV .75, 320x320, slice thickness .8mm, 80 slices, resulting in spatial resolution of .68x.68x.8 and scan time approximately 2:08 minutes. The same parameters were adapted at 3T with TR/TE 5.8/1.5ms. Five patients underwent this exam at both field strengths using 30mL of gadolinium-based contrast with injection rate of 3mL/sec and an auto-triggering tool to detect contrast arrival [3]. By simulating the blood and background signals, based on their T1 values at 1.5 and 3T [1] and measuring actual signal levels in 1.5T and 3T source images, the optimal flip angle that produces maximum contrast was calculated for both fields and adopted in later studies. **2) High resolution, single coil:** to study SNR behavior at higher spatial resolution, three patients were scanned at 3T using slice thickness .5mm, 416x416, and 40°; two patients were scanned at 1.5T with the same parameters, resulting in a spatial resolution of .53x.53x.5 and scan time of 3 minutes. **3) High resolution, 8-channel coil:** to address the SNR reduction at 1.5T when .5mm resolution is used, a study using an 8-channel head coil (MRI Devices Corporation, Waukesha, WI) was performed with the previous parameters. **4) High resolution, 8-channel coil, parallel imaging:** the role of parallel imaging in reducing the scan time, which increases dramatically at high resolutions and could affect signal behavior due to contrast wash out, was evaluated by running the ASSET technique with an ASSET factor of 2 [4] along with the 8-channel head coil, resulting in scan time of 1:30 minutes. Applying the third and fourth cases was not yet feasible at 3T, due to a lack of availability of appropriately configured scanners. Using the results of the first case, estimated SNR levels for 3T for cases 3 and 4 were calculated. SNR measurements were made from the source images from regions of interest within the basilar and right carotid artery at both field strengths for all cases. SNR values and the final MIP image quality were evaluated as acceptable/unacceptable by a radiologist. All spatial resolutions stated above were attained without interpolation techniques (zero filling).

Results and Discussion: SNR measurements for all cases are shown in the table. The simulation revealed that a 40° flip angle optimizes contrast between blood and background at both fields. In case **(1)**, SNR is doubled at 3T compared with 1.5T in agreement with [5]; image quality at both 1.5 and 3T was considered diagnostic. However, background suppression and vessel conspicuity were higher at 3T, as shown in figure 1. In case **(2)**, SNR drops dramatically for both fields resulting in images evaluated as unacceptable at 1.5T, whereas image quality at 3T remains acceptable, as shown in figure 2. This indicates that an SNR of about 20 is desirable. In case **(3)**, using an 8-channel coil at 1.5T improves SNR particularly near the head surface [6], while at the center of the head, where our measurements were made, there is actually a decrease in SNR over the standard head coil. In case **(4)**, adding parallel imaging to the 8-channel coil reduces the scan time to half, but it costs more SNR especially in the central region of the coil, as shown in figure 3, where the image quality was considered unacceptable. The reduction in SNR is not as great as the decrease in scan time would predict, suggesting that higher contrast concentration at earlier stages of the scan may mitigate some of the predicted SNR loss [4].

Conclusion: Higher spatial resolutions are feasible at 3T, due to the increased inherent SNR. Multi-channel coils are limited in improving SNR values in deep intracranial arteries at high spatial resolution for 1.5T. Given these trade-offs, 3T may be necessary to realize diagnostically useful images at approximately 0.5-mm isotropic resolution in the head with CE-MRA. An ongoing challenge at higher resolutions is the issue of increased scan-time. Parallel imaging may facilitate scan-time reduction at 3T; however, at 1.5T SNR is a limiting factor.

References:
[1] Al-Kwifi, O. MRI 2002: 181-187
[2] Bernstein, M. MRM 2001:955-962
[3] Farb, RI. Radiology 2001:244-251
[4] Chen, Q. ISMRM 2003, p1343
[5] McCarthy R. Angio-Club 2003, p16
[6] Gizewski E. ISMRM 2003, p2639

Study Case	Spatial resolution / Scan time / head coil	SNR 1.5T	SNR 3T
First	.68x.68x.8 / 2:08 minutes / single channel	20 ± 1.1	38 ± 4.5
Second	.53x.53x.5 / 3:00 minutes / single channel	11	22 ± 1.0
Third	.53x.53x.5 / 3:00 minutes / 8-channel	9	18*
Fourth	.53x.53x.5 / 1:30 minutes / 8-channel + ASSET	8.1	16.3*

* Indicates estimated values at 3T

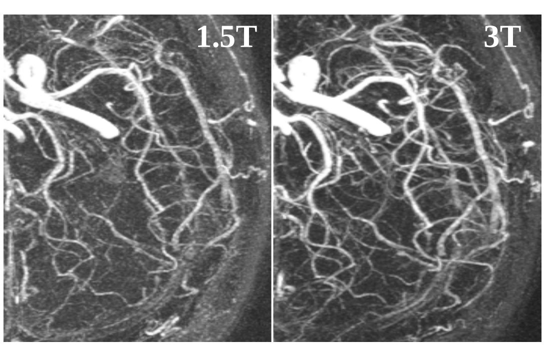

Figure 1. MIP images for the same patient at spatial resolution of (.68x.68x.8) at both field strengths. Image quality at both fields is good, but better background suppression and vessel delineation are noticed at 3T.

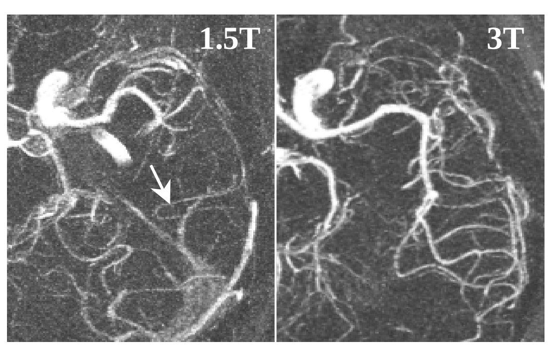

Figure 2. MIP images for different patients at spatial resolution of (.53x.53x.5). Reducing SNR at 1.5T results in poor visualization of blood vessels, where image quality remains acceptable at 3T.

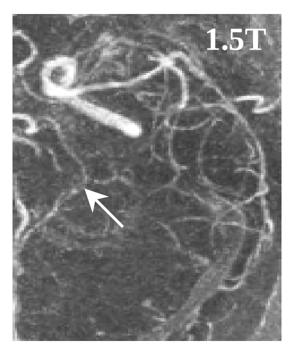

Figure 3. The use of 8-channel and parallel imaging have a limited role in improving SNR at 1.5T.