Comparison of 2D & 3D Time-of-Flight (TOF) MRA of the Carotid Arteries With and Without Parallel Acquisition Techniques

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INTRODUCTION: 3D TOF MRA is a well established high resolution non-invasive way to assess carotid artery stenosis. Although accurate [1], this method is time consuming and especially challenging to perform successfully in the uncooperative patient. 2D TOF has been used as an alternative to 3D imaging because it permits faster scan times and is sensitive to slow flow but it is limited due to its relatively poor spatial resolution [2]. With the advent of parallel acquisition techniques and multi-channel neck coils, examination time can be significantly decreased without compromising spatial resolution. Alternatively, resolution can be improved without prolonging examination time. Parallel imaging has been shown to be useful for improving spatial resolution in imaging the intracranial circulation [3] and decreasing time of acquisition in carotid plaque imaging [4]. To date, no studies have investigated the use of parallel imaging for the evaluation of carotid stenosis. The purpose of this study is to compare 3D and 2D TOF-MRA with and without parallel acquisition techniques, to determine if parallel imaging can be used to improve time of acquisition for conventional 3D TOF without compromising image quality, and to determine if parallel imaging can be used to improve the spatial resolution of conventional 2D TOF. Secondarily, 2D and 3D time of flight imaging with and without parallel imaging will be compared.

MATERIALS AND METHODS: Five consecutive patients presenting for carotid MRA underwent 3D and 2D TOF-MRA with and without parallel acquisition using a 4 channel phased array neck coil and a 12 channel head coil. Images were performed on a 1.5T magnet (Avanto, Siemens Medical Systems, Erlangan, Germany). Conventional 3D imaging was performed using the following parameters: TR/TE 25/7.15/ FA 25^{o}; FOV 210 mm, voxel size 0.7 x 0.5 x 0.9 mm, and matrix 288 x 384. 3D TOF with parallel imaging (acceleration factor of 3) was performed using the same parameters except: FOV 230 mm and a matrix of 314 x 448 with the addition of parallel imaging in order to maintain voxel size. The time of acquisition was decreased from 6:21 minutes to 2:40 min. Conventional 2D TOF was performed using the following parameters: TR/TE 27/6.88/ FA 35^{o}, voxel size of 0.9 x 0.8 x 3.0 mm and a matrix of 164 x 256. With parallel imaging (acceleration factor 3) resolution was improved to achieve a voxel size of 0.4 x 0.4 x 3.0 mm with a 416 x 512 matrix, while time of acquisition was kept constant at 3:40 minutes (3:42 minutes with parallel imaging). Quantitative assessment was performed by calculating signal-to-noise ratio (SNR) and contrast-to-noise ratios (CNR) in the distal common carotid artery for each method of imaging. Qualitative assessment was performed by two neuroradiologists blinded to the imaging method. Subjective assessment of image quality, noise, degree of stenosis using the NASCET criteria, and degree of confidence in diagnosis was performed using a 4 point scale. A pairwise comparison was performed using a Wilcoxin signed-rank test.

Fig 1. 3D MIP images of the same carotid bifurcation using parallel imaging techniques (left) and without parallel imaging techniques (right)

RESULTS: SNR was decreased for both 3D and 2D TOF-MRA with parallel acquisition techniques as shown in Table 1, but was still adequately high for both groups. Qualitative parameters such as overall quality are not significantly different as shown in Table 1. Image quality was not subjectively reduced using parallel acquisition techniques, as shown in Figure 1.

	Conventional TOF vs. TOF with Parallel Imaging					
TABLE 1	**3D**	**3D IPAT**	**P-value**	**2D**	**2D IPAT**	**P-value**
Average SNR	106.7	82.3	$p \leq 0.0625$	67.0	56.1	$p \leq 0.125$
Average CNR	81.7	63.3	$p \leq 0.125$	57.0	43.2	$p \leq 0.125$
Overall Quality	2.2	2.4	$p \leq 0.5$	2.6	2.6	$p \leq 0.5$

*Note: Average Overall Quality on a scale of 1-4
(1=Excellent, 2=More than adequate for diagnosis, 3=Adequate for diagnosis, 4=Nondiagnostic)

CONCLUSION: 2D and 3D TOF-MRA with and without parallel imaging techniques of the carotids are comparable in image quality. These techniques can be used to either reduce the time of the examination in 3D imaging or improve spatial resolution in 2D imaging, without significantly compromising image quality or diagnostic reliability in the qualification of carotid stenosis, although further investigation with larger sample size is needed.

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