

3D MR Imaging of Intraplaque Hemorrhage (MRIPH) and 3D TOF MRA at 3T for Atherosclerotic arterial wall evaluation: a comparison with 2D multi-contrast MRI

James Qiupeng Zhan¹, Alan Moody^{1,2}, Cristina Nasui², and Herve Jeufack¹

¹Sunnybrook Hospital, Toronto, Ontario, Canada, ²Medical Imaging, University of Toronto, Toronto, Ontario, Canada

Introduction. 2D multi-contrast MRI sequences are currently used to evaluate atherosclerotic plaques through plaque component analysis and characterization. A drawback with these techniques includes calcification appearing as hypointense, which makes distinguishing between calcification areas and lumen difficult, this protocol is time consuming and the coverage area is limited to the carotid bifurcation. MR-intraplaque hemorrhage (MRIPH) is a high-resolution technique that shows IPH as hyperintense in advanced atherosclerosis. The use of this sequence is important as IPH is considered a strong indication of the progression level in atherosclerosis. The visualization of vessel lumen can be helped by using 3D time-of-flight MR angiography (TOF MRA) imaging in order to differentiate calcification and the vessel lumen. This is not always possible with 2D techniques due to the hypointense signal obtained at the calcification site and within the lumen. The aim of this study was to assess whether 3D MRIPH and 3D TOF MRA at 3T could be used for arterial wall evaluation independent of 2D multi-contrast MRI sequences.

Materials and Methods. 10 patients with confirmed 30 to 70% carotid stenosis by clinical MRA were recruited and scanned in a 3T scanner (Philips Achieva, R3.2.1, Best, the Netherlands) with a 16 elements neurovascular coil (Philips Achieva, SENSE-NV-16). 3D High-Spatial-Resolution MRIPH was performed using a 3D Fast Field Echo (FFE) sequence in the coronal plane (100 slices, scanning time: 8'54", TE= 4ms, TR=11ms, matrix 512x256, FA=15°, FOV=27x19cm, NEX=4, slice thickness=0.5mm). 3D TOF MRA was performed using 3D FFE sequence in the axial plane (160 slices, scanning time: 5'59", TE=3.5ms, TR=26ms, matrix 360x232, FA=18°, FOV 19x19cm, NEX=1, slice thickness=0.7mm). For 2D multi-contrast MRI, cardiac gated, double inversion recovery FSE sequences with fat suppression were performed to get 16 slices. T2-weighted, PDW images and pre- and post-contrast T1-weighted scans were performed. Coronal MRIPH images were reformatted into the axial plane. Custom-designed plaque analysis software QPlaque (Medis, The Netherlands) was used for segmenting lumen boundary on 3D TOF and outer wall boundary on 3D MRIPH, as well as both boundaries on the 2D multi-contrast images. The measurements for lumen area, outer wall area, vessel wall area, and maximum vessel wall thickness on each axial location of interest were compared on the 2D and 3D images. Two trained observers analyzed the 3D TOF and 3D MRIPH images and inter-observer variability was calculated using a coefficient of variation.

Results. The image quality was sufficiently high for delineating the lumen from the 3D TOF image and outer vessel wall from 3D MRIPH image (Fig.1) improving the measurements of lumen area, outer wall area, vessel wall area, and maximum vessel wall thickness. Also as seen from Fig. 2 and 3, there is very close agreement between 3D MRIPH combined with 3D TOF MRA when compared to the 2D multi-contrast MRI. Correlation coefficients of lumen, outer wall, vessel wall and maximum wall thickness were 0.984, 0.947, 0.962 and 0.876, respectively (P<0.001). Inter-observer correlation coefficient for outer wall was 0.806 and 0.930 for lumen (P<0.001).

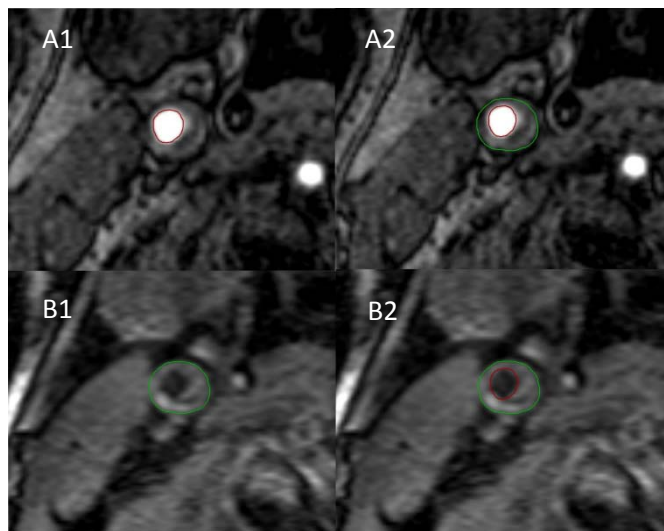


Fig.1. Axial 3D MRIPH (outer wall) and TOF images (inner wall) showing carotid artery (A1, B1) and contoured outer wall and lumen boundary images combined(A2, B2)

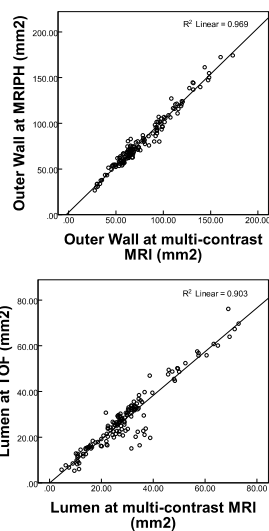


Fig 2. Illustration of lumen area and outer wall area measurement and highly correlation between 3D MRIPH and TOF to 2D multi-contrast MRI.

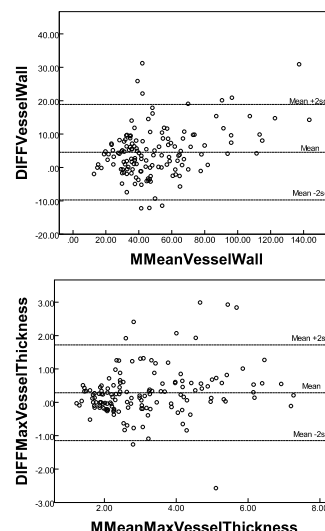


Fig 3. Bland & Altman plots for wall area and maximum vessel wall thickness measurement showing very close agreement in 3D MRIPH and TOF to 2D multi-contrast MRI.

Conclusion. In this study, an arterial wall evaluation method is proposed based on 3D MRIPH and 3D TOF MRA at 3T. Statistically, the combination of these two methods give a thorough description of atherosclerotic vessel wall disease load when compared to multiparametric methods used for assessment of disease (multi-contrast MRI). The high resolution MRIPH technique obtained on the 3T scanner potentially overcomes some problems of prolonged scan time and registration of images from multiparametric 2D data sets.

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