Plaque characteristics, burden and distribution assessment with high-resolution intracranial vessel wall imaging at 3 tesla MRI

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Introduction. Relatively few studies have assessed the morphological characteristics of intracranial atherosclerotic plaques. The remodeling pattern and plaque distribution within the plaque, e.g. superior, inferior, dorsal or ventral are one of the few characteristics that have been assessed in middle cerebral artery (MCA) stenosis[1]. Several smaller studies have proposed specific intracranial plaques characteristics such as eccentricity and enhancement[2-4]. However, these and other plaque characteristics still remain poorly investigated. In light of total plaque burden even less is known and it can be hypothesized that, similar to the extracranial arteries, preferential locations can be found. Therefore in this study we qualitatively evaluated intracranial plaque characteristics (contrast enhancement, thickening and configuration), total plaque burden and distribution in patients with an MCA stenosis, using a 3D T_1-weighted volumetric isotropic turbo spin-echo acquisition (VISTA) vessel wall sequence at 3 tesla (3T).

Figure 1. A 57-year-old male patient with a left MCA stenosis. (A) Transverse TOF-MRA shows a stenosis of the right MCA (arrow). Transverse T_1w VISTA images show a left MCA plaque (arrows in B) before contrast administration. The plaque enhances after contrast administration (arrow in C). Zoom-box shows sagittal view of the eccentric plaque (black arrow).

Materials and Methods. Institutional Review Board approval was obtained for this retrospective study. All patients gave written informed consent. Chinese stroke and transient ischemic attack patients presenting with a symptomatic MCA stenosis were included in this study. Imaging was performed on a 3T Achieva MR system (Philips Healthcare, Cleveland, OH, USA) with 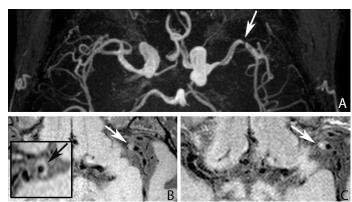an 8-channel SENSE head coil. The protocol included a T_1-weighted (T_1w) VISTA sequence, before and after (83% of patients) contrast administration, and a Time-Of-Flight Magnetic Resonance Angiography (TOF-MRA) sequence. Before acquisition of the contrast enhanced T_1w VISTA sequence, 0.1 mL/kg of a gadolinium-containing contrast agent (Dotarem, Gadoteric acid 0.5 mmol/mL, Guerbet, Roissy CdG Cedex, France) was administered to the patient. The following scan parameters were used: T_1w VISTA: field-of-view (FOV) 200x167x45mm^3, acquired resolution 0.6x0.6x1.0mm^3, repetition time (TR) 1500ms, echo time (TE) 35ms, scan duration 6:51min; TOF-MRA sequence: FOV 200x200x56mm^3, acquired resolution 0.4x0.6x0.7mm^3, TR/TE 23/3.5ms, scan duration 3:07min. Images were reviewed by ND. Statistical analysis was performed using SPSS 20 for Windows. Chi square tests were used to assess associations between different plaque characteristics. Statistical significance was set at $p<0.05$.

Results. Between February and September 2014, nineteen patients (7 females; mean age 67 years, range 47-81 years) with an MCA stenosis underwent 3T imaging at various times after symptom onset. Intracranial vessel wall lesions were identified in 18 patients, totaling 57 lesions in 494 segments (12% of segments). Plaque burden and characteristics are presented in Table 1 and 2, respectively. Most of the lesions were present in the anterior circulation. Seventy-five percent of the lesions were eccentric (Figure 1) and there was a significant ($p<0.001$) association between eccentricity and a focal thickening pattern and between concentricity and a diffuse thickening pattern in plaques of the anterior circulation but not of the posterior circulation. When differentiating between asymptomatic (67% of lesions) and symptomatic (33% of lesions) lesions, a significant association ($p<0.05$) was found between eccentricity and asymptomatic lesions, but not for enhancement or a specific thickening pattern.

Table 1. Plaque burden in 18 patients with MCA stenosis

Location	Right*	Left*	Total (n=57)*
Internal carotid artery	10	8	18
Distal carotid segment	6	3	9
Bifurcation A1-M1-ICA	4	5	9
Middle cerebral artery	10	17	27
M1 segment	9	13	22
Bifurcation M1-M2	0	2	2
M2 segment	1	2	3
Anterior cerebral artery	0	2	2
A1 segment	0	1	1
A2 segment	0	1	1
Basilar artery	-	-	3
Posterior cerebral artery	2	5	7
Bifurcation BA-P1	2	2	4
P2 segment	0	3	3
Total number of lesions	**22**	**32**	**57**

*Number of lesions at location.

Table 2. Plaque characteristics of 57 plaques in patients with MCA stenosis

Plaque characteristic	Anterior circulation*	Posterior circulation*	Total (n=57)*
Enhancement			
Yes	24	1	25
No	16	5	21
NA	7	4	11
Configuration			
Concentric	12	2	14
Eccentric	35	8	43
Thickening			
Focal	33	9	42
Diffuse	14	1	15
MRA			
Normal	21	6	27
Irregular	10	2	12
Stenosis	12	2	14
Occluded	1	0	1
Irregular and occluded	3	0	3

*Number of lesions at location. NA: no post-contrast scan available.

Conclusion. Intracranial vessel wall imaging using a 3D T_1w VISTA vessel wall sequence at 3T was able to identify basic intracranial plaque characteristics and assess total plaque burden and distribution. We demonstrate that intracranial atherosclerotic plaques are mainly associated with an eccentric configuration and a focal thickening pattern. Most of the lesions were found in the anterior circulation, corresponding to similar distributions found for ischemic strokes[5].

References. [1]Zhu et al., AJNR, 2013; [2]Dieleman et al., Neurology, 2014; [3]Swartz et al., Neurology, 2009; [4]Vergouwen et al., Arch. Neurology, 2011; [5]Bogousslavsky et al., Stroke, 1988.