Correlation between Plaque Eccentricity and Vessel Remodeling in the Human Femoral Artery: a Morphology Investigation by High Resolution MRI

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Background: Plaque eccentricity and arterial remodeling are two important markers of atherosclerotic plaque burden and subsequent cardiovascular events[1-3]. Previous studies have demonstrated that the occurrence of coronary expansive (positive) remodeling is associated with eccentric lesion and constrictive (negative) remodeling is associated with concentric lesion[4]. Few studies, however, have been conducted to study this relationship in peripheral artery disease.

Purpose: To investigate atherosclerotic vessel wall morphology in the femoral artery, in particular lesion eccentricity and remodeling and their relationships using images acquired with high resolution multi-sequence MRI in the femoral artery.

Methods: Fourteen subjects (Ankle-Brachial Index <1.00) were enrolled in this study for high resolution multi- sequence MRI (2D TOF, T1WI, PD and T2WI; slice thickness 3 mm, no gap, FOV 120×120 mm, Matrix 192×192) on 1.5T scanner (Siemens, Sonata). The imaging coverage extends from the common femoral artery (CFA) to the proximal superficial femoral artery (SFA). Only the SFA images were included in this study. Multi-sequence cross-sectional images, which were matched using the CFA bifurcation as a fiducial marker, were independently interpreted by two reviewers. CASCADE software was used to outline the lumen area (LA) and total vessel area (TVA)[5]. Slices with a Maximum wall thickness larger than 1.5mm were selected as lesion slices[6]. Remodeling index (RI) was defined as lesion TVA divided by mean reference TVA (the average of the most normal-looking cross-sections at the proximal and distal segments). Positive remodeling was defined as a remodeling index >1.05, negative remodeling as a remodeling index <0.95, and intermediate remodeling as a remodeling index between 0.95 and 1.05. The disease eccentricity index was calculated by the formula: (Max wall thickness -Min wall thickness)/ Max wall thickness (Fig 1 ,2). The lesion was defined as eccentric if the index was >0.5 and as concentric if ≤0.5. Normalized wall index (NWI), which was used as a marker of disease severity and plaque burden, was calculated at each slice as wall area (WA=TVA-LA) divided by TVA.

Results: A total of 71 femoral artery lesion slices were examined. Associations of presence of eccentricity and remodeling with NWI, lumen area, wall area, total vessel area and wall thickness (Max, Min and Mean) are presented in Table 1. 77.46% (55/71) slices were eccentric and 22.54% (16/71) were concentric. For arterial remodeling, 59.15% (42/71) were positive, 12.68% (9/71) were negative and 28.17% (20/71) were intermediate. The distributions of plaque morphology in three types of remodeling were significantly different (P<0.05). Concentric lesions were more frequently observed in positive remodeling. 81.25% (13/16) concentric lesions were positive remodeling. But for the eccentric lesions, only less than half of them occurred with positive remodeling (47.27% [26/55]).

Conclusion: These results demonstrate that eccentric lesions occur more frequently than concentric in atherosclerotic femoral arteries. Concentric plaque is more common in lesions with positive remodeling than in negative remodeling, which is inconsistent with former study results obtained from coronary arteries[4]. This difference may be caused by the indigenous condition of the femoral artery wall and possible different plaque compositions from coronary artery. Further studies are required to understand the relationship between plaque components, plaque morphology, and vessel remodeling in the femoral artery.

Table 1: Comparison of lesions with different eccentricity and remodeling

	Eccentricity		P value (T test)	Remodeling			P value (ANOVA)
	Eccentric	Concentric		Positive	Intermediate	Negative	
NWI	0.76±0.09	0.84±0.09	0.884	0.80±0.09	0.74±0.09	0.76±0.13	<0.05
Lumen area (mm^2)	11.95±6.62	4.82±3.58	<0.05	8.46±6.10	14.54±6.40	9.82±6.95	<0.05
Wall area (mm^2)	35.55±12.57	24.90±5.77	<0.05	30.82±11.34	40.08±10.99	28.60±13.67	<0.05
Total vessel area (mm^2)	47.50±17.20	29.72±7.02	<0.05	39.28±16.23	54.62±14.23	38.41±17.77	<0.05
Max wall thickness (mm)	3.52±1.12	2.37±0.42	<0.05	3.13±0.96	3.69±1.25	2.93±1.37	0.117
Min wall thickness (mm)	0.95±0.25	1.54±0.43	<0.05	1.14±0.47	1.01±0.21	0.96±0.22	0.266
Mean wall thickness (mm)	1.99±0.49	1.91±0.42	0.991	1.96±0.40	2.06±0.50	1.80±0.67	0.408

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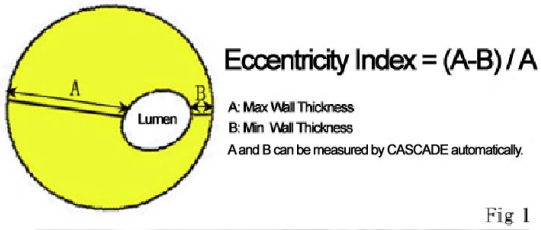

Fig 1

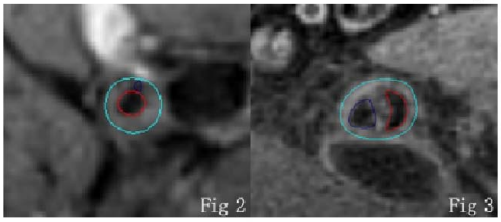

Fig 1: Eccentricity Index = (A –B)/A. Max wall thickness (A) and Min wall thickness (B) can be calculated by CASCADE automatically.
Fig 2-3: Cross-sectional T1 weighted images show examples of atherosclerotic femoral arteries with eccentricity index of 0.27 and 0.83. They have remarkably different morphologies, but the NWI values are similar (0.80vs.0.85). (Outer wall: light blue; Lumen: red circle; Calcification: dark blue)