

A Reproducibility Study in PAD Patient Plaque Burden Analysis Approach with Multi-Contrast Weighting MRI

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Introduction

Peripheral arterial disease (PAD) affects over 10 million people in the United States alone and highly correlates with the increased rates of functional impairment and risk of cardiovascular events^[1]. It is believed that plaque burden in the superficial femoral arteries is an important indicator of the presence and severity of peripheral artery disease. In our ongoing PAD trial, plaque burden in the lower extremities is used to compare with well defined indicators of peripheral vascular disease. The plaque burden measurement is based on the Proton Density Weighted (PDW) and Time-of-Flight (TOF) MR images. Since this study will last 3 to 4 years and multiple readers will be involved in the plaque burden evaluation at different stages, the quality and reliability of PAD imaging and analysis method are crucial.

Purpose

This study has two purposes: a) evaluate the reproducibility of multi-contrast MR imaging technique that is used for femoral artery scan; b) evaluate the inter-reader plaque analysis variability based on multi-contrast MRI data in PAD evaluation.

Methods

Fifteen subjects with PAD as defined by the ankle brachial index (ABI < 0.90) ^[2] were selected from an ongoing study of functional impairment in PAD. They were scanned on a 1.5T MR scanner (Sonata, Siemens Medical Systems) with a dedicated specially designed leg coil (NOVAL Medical). Ten of them were randomly selected for a follow up scan approximately 2-3 weeks apart. At the most frequently occurring site of atherosclerosis below the inguinal ligament, ten consecutive axial MR images of the superficial femoral artery (SFA) were captured in PDW and TOF sequences. The imaging parameters are: PDW: TR=2160ms, TE=5.6ms and TOF: TR=28ms, TE=7.2ms, FOV=12x12cm, matrix=192x192. Since the coil used in this study keeps the subject's leg position fixed, the images in both contrast weightings were automatically registered by using the native scan prescription software. The image data were analyzed with in-house developed vascular plaque analysis software, CASCADE ^[3] (developed by Vascular Imaging Laboratory, University of Washington). The femoral vessel segmentation was performed by detecting lumen and outer wall boundaries using PDW and TOF data as described in our previous work ^[3]. Figure 1 is an example of the analysis result.

Performance Evaluation

Two experiments were designed and conducted to achieve the study purposes:

1) MRI imaging reproducibility test: ten subjects were scanned twice with 2-3 weeks apart. In each scan, 10 slices were acquired in femoral artery. Because the interval between the two scans is short, the change in plaque can be ignored so that the difference between two scans is regarded majorly from imaging process. An experienced reader analyzed the 20 scans with blinded subject information. To evaluate the reliability of MR imaging technique used in this trial, we quantitatively compared the two scans of each subject. Normalized wall plaque volume, max wall thickness and mean wall thickness were computed. Among all subjects, the comparison in these three measurements showed very high correlation. Figure 1 illustrates the max wall thickness correlation between two readings. Correlations of other measurements are in Table 1.

2) Inter-Reader Variability Test: To evaluate the reproducibility of inter reader reading, the first scan of 15 subjects were reviewed by two readers blinded to each other. The measurements of normalized wall plaque volume, max wall thickness and mean wall thickness in their readings were compared. The statistical results are in Table 2 which demonstrated a high correlation between the two readers even though the mean wall thickness is a little low.

Summary

In a long term, large PAD clinical trial, the reproducibility of MRI based plaque burden evaluation is very important to the success of study. To evaluate the reliability of multi contrast MR imaging technique on femoral artery, two variability studies on a subset of trial data were conducted. The statistical analysis on quantitative plaque measurements demonstrated that reproducibility of MR imaging is satisfactory in PAD study. Using this technique can also help reduce the Inter-Reader variability in follow up plaque analysis. This means that current techniques used in MR imaging and plaque burden analysis can provide effective and reliable quantitative measurements for peripheral arterial disease evaluation.

Reference:

1. Toussaint et al. Circulation 94:932-938, 1996.
2. McDermott, JAMA 2004.
3. Kerwin W, et al, Top Magn Reson Imaging. 2007;18(5):371-8.

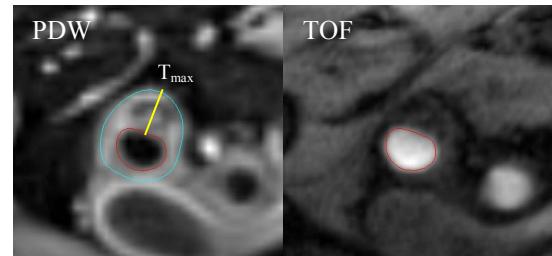


Figure 1: Example of Vessel segmentation. Two contrast weightings, PDW and TOF. Red contour: Lumen, light blue contour: outer wall. Yellow line: location of the max wall thickness T_{max}

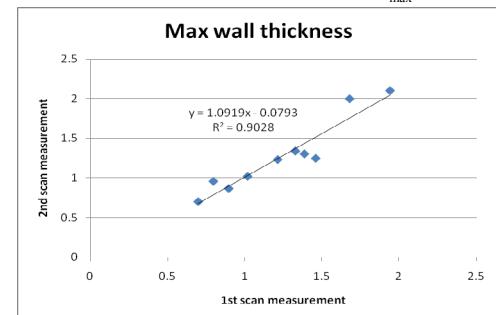


Figure 2: correlation of max wall thickness between two scans.

Table 1: Reproducibility in **Intra-Reader** Variability Test (N=10)

MRI-Measures (normalized values)	Pcc	P Value
Plaque volume	0.892	< 0.001
Max thickness	0.960	< 0.001
Mean thickness.	0.928	< 0.001

Table 2: Reproducibility in **Inter-Reader** Variability Test (N=15)

MRI-Measures (normalized values)	Pcc	P Value
Plaque volume	0.894	< 0.001
Max thickness	0.961	< 0.001
Mean thickness.	0.801	< 0.001