

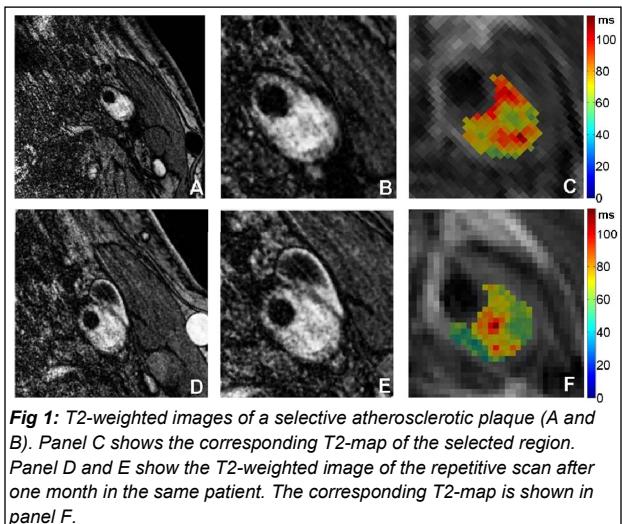
## Reproducibility of T2-measurements in human carotid plaques

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### Introduction:

Identifying carotid atherosclerotic plaques that are prone to rupture can greatly improve cardiovascular prevention strategies. Magnetic Resonance Imaging (MRI) plaque characterization has recently shown to provide reliable measurements of vessel wall dimensions as well as plaque morphological characteristics<sup>1,2</sup>. Examples are the lipid-rich necrotic core and intraplaque hemorrhage, both identified by several histopathological studies to characterize the vulnerable plaque. However, scanner type, radio frequency coil configuration and the surrounding anatomy of the patient can greatly influence image quality and signal intensity. T2-values provided by MR relaxometry has shown to be a more accurate and precise measure to characterize and identify specific tissues in a wide range of patients and conditions. We hypothesize that MR relaxometry can greatly improve atherosclerotic plaque characterization. Here, we present reproducibility data of T2-measurements in a selected patient population with significant carotid atherosclerosis.



**Fig 1:** T2-weighted images of a selective atherosclerotic plaque (A and B). Panel C shows the corresponding T2-map of the selected region. Panel D and E show the T2-weighted image of the repetitive scan after one month in the same patient. The corresponding T2-map is shown in panel F.

### Methods:

In each of the 20 subjects of the study two 3.0 Tesla MRI carotid scans were performed on a Philips Intera scanner within one month. Axial images were acquired, using a 8 channel carotid coil (Shanghai Chenguang Medical Technologies, China). T2-measurements were performed by using a sequence developed by Warntjes *et al*<sup>3</sup>. For measuring T2, 5 echoes were obtained at TE=20, 40, 60, 80, 100 ms. Monoexponential fitting was performed in each voxel. Imaging resolution was  $0.5 \times 0.5 \text{ mm}^2$ , FOV  $60 \times 60 \text{ mm}^2$ , 12 slices of 2 mm thickness were acquired with a total acquisition time of 7 min. In addition, high resolution unilateral axial turbo spin echo T1w, T2w, PDw and Time of Flight (TOF) image stacks were acquired at late diastole (ECG gated). Sequence parameters were: double inversion-recovery black blood prepulse, T1w: TE 8 ms and repetition time (TR) according to heart rate (around 800 ms), T2w: TE 50 ms and TR according to heart rate (around 1700 ms); PDw: TE 8 ms and TR same as T2w; TOF: TE 7 ms, TR around 35 ms and flip angle 20°, slice thickness 2 mm, non-interpolated pixel size  $0.25 \times 0.25 \text{ mm}^2$  and active fat suppression (SPAIR) for T1w, T2w and PDw, FOV  $60 \times 60 \text{ mm}^2$ . To compare the means of the T2 values of both timepoint an unpaired t-test was used. Selection of suitable patients was based on plaque size and image quality.

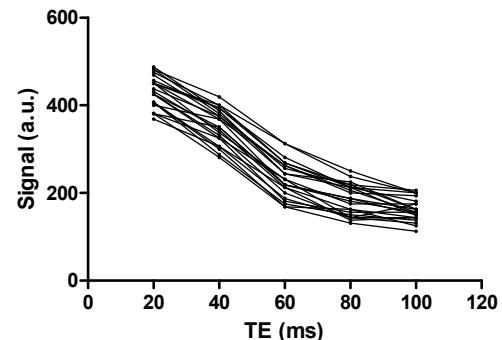
### Results and Discussion:

From the 20 available repetitive measurements, we identified 7 patients with a large atherosclerotic plaque ( $> 25 \text{ mm}^2$ ) and repetitive high quality images. Cross-sectional images of 4 different weightings from two different time points of each artery were matched based on the carotid bifurcation on TOF. Plaques clearly visible at both time points were selected for manual delineation. Figure 1 shows an atherosclerotic plaque at both timepoints (B and E) and the T2-maps of the manual delineated region of interest (ROI). Typical T2-decay curves within a plaque are shown in figure 2. The mean T2-value of measurement 1 (46.2 ms, SD 17.8 ms) was not significantly different from measurement 2 (46.1 ms, SD 18.0 ms;  $p = 0.97$ ). The standard deviation of the paired differences was 5.2 ms. Figure 3 shows a Bland-Altman plot of the difference versus the average of the T2-values. The largest T2-value of 81.2 ms was measured in the plaque displayed in figure 1. Encountered difficulties were the manual selection of the ROIs and the limited SNR of the images acquired at large TEs. The SD of the paired differences could be further reduced if the repeated sessions are accurately registered.

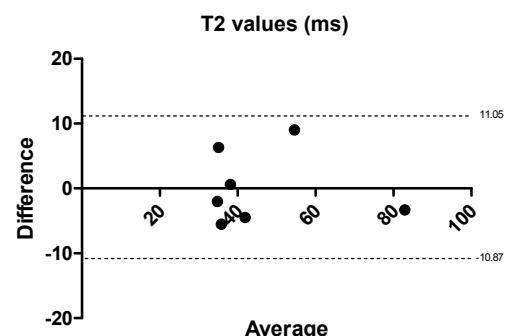
### Conclusion:

We have successfully applied MR relaxometry to calculate T2-values in human carotid plaques. In addition, our manual repetitive delineation method of advanced atherosclerotic plaques has small measurement variability, giving support to the feasibility to use T2-measurements to characterize human atherosclerotic plaques.

**References:** <sup>1</sup>Bartlett *et al.* AJNR; 28:1095. <sup>2</sup>Wargyropoulou *et al.* Pediatr Radiol; 37:1191.  
<sup>3</sup>Warntjes *et al.* Magn Reson Med; 60:320



**Fig 2:** T2-decay curves per voxel in a relatively homogeneous part of an atherosclerotic plaque. Measurements were obtained at TE=20,40,60,80,100 ms.



**Fig 3:** Bland-Altman plot for the T2 values in patients with carotid atherosclerosis. The dashed lines indicate 95% limits of agreement.