Objective
Quantification of carotid plaque volume and tissue composition may help assess plaque progression/regression and risk-stratification. Ultrasonography is limited by operator-variability, while MRI is expensive and requires specialized surface coils. CTA is readily available and follows standardized protocols providing high-resolution images. We assessed the feasibility and reliability of geometric and morphologic measurements of carotid plaques using CTA and computed the minimum detectable change (MDC) in plaque features detectable by this approach.

Methods
Cervical CTAs of carotid stenosis patients were analyzed by two observers using a semi-automatic image-analysis program (VascuCAP) yielding 86 observations. One observer repeated all the analyses four weeks later. Plaque-volume and percent-stenosis (by diameter and area) were computed. Tissue composition was defined using Hounsfield intensity-thresholds for calcium (CA), lipid-rich necrotic core (LRNC), and intra-plaque hemorrhage (IPH). Reliability of measurements was assessed by intra/inter-class correlation (ICC). Dice Similarity Coefficient (DSC) and Modified Hausdorff Distance (MHD) assessed reliability of geometric measurements. We also determined the minimum amount of change in plaque features detectable by our approach.

Results
Patients: 51% male, mean age 70yrs, mean stenosis 43%, and mean(SD) plaque volume 758.1mm$^3$±371.7. Intra-class correlation for tissue composition measurements were high, ranging from 0.99 for calcium to 0.84 for hemorrhage, and inter-class correlation was also high, ranging from 0.98 (CA) to 0.87 (IPH). Plaque geometric measurements showed high intra-observer (DSC 0.94±0.05, MHD 0.17mm±0.13) and inter-observer (DSC 0.93±0.07, MHD 0.20mm±0.15) agreement for luminal outlines. This approach can detect a change of at least 43.8mm$^3$ (5.7%) in plaque volume, 1.7mm$^3$ in CA, 5.8mm$^3$ in LRNC, and 7.0mm$^3$ in IPH (if one observer repeated the measurements); and 67.5mm$^3$ (9.1%) in plaque volume, 2.3mm$^3$ in CA, 6.2mm$^3$ in LRNC, and 6.6mm$^3$ in IPH (for two different observers).

Conclusions
Carotid plaque burden and tissue constituents are measured reliably from clinical CTAs using a semi-automatic image-analysis program. This approach can quantify changes in plaque volume and composition over time and after treatment. The minimum change in plaque volume detectable is about 44mm$^3$ (6%) if the same observer takes the measurement, and 68mm$^3$ (9%) for different observers. A minimum change of about 6mm$^3$ in LRNC size and 7mm$^3$ in IPH is also detectable.

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