Echo CT Imaging of Human Carotid Atherosclerotic Plaques In Vitro

Renate Boekhoven¹, Marcel Rutten¹, Richard Lopata¹, Marc van Sambeek², Frans van de Vosse¹
¹University of Technology Eindhoven, ²Catharina Hospital, Eindhoven

Introduction

Carotid endarterectomy (CEA) is the procedure of choice in patients with a symptomatic 70-99% stenosis. The selection for CEA is based on stenosis size only. However, CEA is only beneficial for patients with unstable plaque (16%)¹. Hence, identifying plaque stability at an early stage would permit timely intervention, while substantially reducing overtreatment.

Innovation: Echo-CT

Intact CEA specimens, provided by Catharina Hospital, were cannulated and fixed in an experimental set-up (Fig. 1). This set-up enables rotation of the specimen, while the specimen is being pressurized and imaged with ultrasound (US), echo-CT. The rotation overcomes acoustic shadowing effects (Fig. 2), which are due to calcifications. The specimen was rotated and imaged in steps of 10°.

Further steps for the reconstruction are visualized in Figure 4, the steps include: inner and outer wall detection (by means of a sustain attack filter (SAF²)), correlation, harmonic fitting and circular transformation. Finally US reconstruction will be verified with µCT (Scanco Medical).

3D reconstruction analysis and verification

A post-processing tool was developed to analyze 36 US datasets. In Figure 3, the first step of the post-processing is visualized, where longitudinal data is transformed into transverse oriented data.

Figure 1: Image and schematic representation of the experimental set-up. Distension was measured with an ultrasound system (ARTLAB, Esaote Netherlands), and pressure was measured by a pressure.

Figure 2: Atherosclerotic carotid specimen imaged with echo-CT at 0° (a) and 180° (b). Acoustic shadow is visible over the entire posterior wall in (a), while the same wall is clearly visible at the anterior site in (b).

Figure 3: First step in the post-processing, to be able to reconstruct a 3D geometry, where longitudinal data is converted to transverse sections, to enable the 3D reconstruction. To obtain transverse sections, 1 line for 1 frame per rotation was stacked, obtaining a cross-section.

Figure 4: Overview of the post-processing steps for the echo-CT data. To obtain 1 cross-section (d), starting from Fig. 3 steps a-d were repeated for all lines, by stacking all the cross sections a 3D reconstruction (f) of the plaque (e) from a single time frame was obtained. µCT will be used to verify the reconstruction because its resolution.

Conclusion

We successfully developed an experimental set-up, which enables pressurization and imaging of atherosclerotic segments in 3D. Furthermore, the post-processing tool allows the 3D reconstruction of the echo-CT dataset.

Future Work

The reconstruction will in the future allow as input for inverse numerical analysis to determine the mechanical properties of the plaque components. Firstly the reconstruction will be verified with µCT.

References