Atherosclerosis is characterized by the development of plaques in the arterial wall, ultimately leading to heart attacks and strokes. Quantitative measurements of the progression and regression of carotid plaque burden are important in monitoring patients and evaluating new treatment options. 3D carotid ultrasound (3D US) has the potential to be an effective method to monitor the progression of carotid artery plaques in symptomatic and asymptomatic patients. To meet this challenge, we developed a 3D carotid US system that allows detailed studies of plaques in 3D. Our software includes 3D reconstruction, viewing, and segmentation of carotid plaques, surface morphology analysis, and registration software to allow quantitative tracking of plaque changes. We used our system to examine the detailed relationship between the 3D US-based measurement of plaque volume, the 3D scanning parameters, volume measurement variability, and plaque surface morphology.

In this paper, we describe the acquisition and reconstruction of 3D carotid US images, and extended concepts used in intima-media thickness (IMT) measurements based on 2D images to a metric we call the 3D vessel-wall-plus-plaque thickness (3D VWT), which is obtained by computing the distance between the carotid wall and lumen surfaces on a point-by-point basis in a 3D image of the carotid arteries. The VWT measurements can be superimposed on the arterial wall to produce the 3D VWT map. Since changes in plaque thickness is important in monitoring patients who are at risk for stroke, we also compute the change of VWT by comparing the 3D VWT maps obtained at two different times. To facilitate the visualization and interpretation of the 3D VWT and 3D VWT-Change maps, we developed a technique to flatten these maps in an area-preserving manner.

Learning Objectives:

1. Understand the limitations of conventional carotid ultrasound imaging
2. Understand the methods that can be used to overcome the limitations of the use of conventional ultrasound to monitor progression of carotid disease
3. Understand the advantages of 3D ultrasound images to monitor progression of carotid disease