Using Subdivision Surfaces to Represent Bifurcations for Use in Finite Element Modeling of Abdominal Aortic Aneurysms

Since abdominal aortic aneurysms (AAAs) represent a leading cause of death in the U.S., finite element modeling of AAAs is being used to help physicians better predict location and risk of rupture. To increase accuracy, the iliac bifurcation should be included in finite element models of AAAs; however, 3D reconstruction of vessel geometry and generation of finite elements are problematic at bifurcations. Two methods have been used to represent AAAs: NURBS (non-uniform rational b-splines) and triangular meshes, but both methods present problems. NURBS representations require at least three separate surfaces to be patched together at bifurcations, creating discontinuous seams. Triangular meshes can cause problems at bifurcations because of triangles of bad aspect ratio. Regardless of whether NURBS or triangular meshes are used, the thrombus and lumen wall surfaces are generated independently. This makes it difficult to create a finite element mesh for the volume between the two surfaces when the two surfaces are separated by a small distance. To solve these problems, this project will implement an interpolatory quadrilateral subdivision algorithm in Matlab™/C++ to create surfaces without cusps or seams directly from a series of segmented 2D computed tomography (CT) images. The thrombus and lumen walls will be constructed with corresponding faces so that a finite element mesh can be generated from the volume between the two surfaces. When complete, this program will generate a smooth subdivision surface directly from segmented CT images, facilitating finite element analysis of AAAs at the bifurcation. This method could be applied to both vascular and pulmonary modeling to improve finite element analysis at bifurcations.

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