APPLICATION OF GID TO 3D BIOMECHANICS PROBLEMS, INTERFACING WITH ABAQUS AND FEAP

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SUMMARY: In the context of a biomechanic research work for modelling arterial wall soft tissue, we have been employing GiD for the development of finite element models. The object is, starting from complex 3D geometries obtained from in-vivo images, to develop F.E. models, analyse them with ABAQUS and FEAP (for which purpose the appropiate interfaces with GiD have been developed), and finally visualize the results. In order to determine reliable models for the development of the atherosclerosis, a description of the hemodynamic conditions in the places of interest is detailed, being necessary a numerical tridimensional simulation that allows to calculate the distribution of shear stress in the interface and the stress state in the arterial wall. For that, initial geometry data are obtained by angiographies, determining the lumen, and IVUS (IntraVascular Ultrasound System), providing information about the morfology and structure of the arterial wall. The present paper focuses on the treatment of real geometric data of an arterial bifurcation with GiD (imported as IGES), and presents the results (also using GiD) of stresses in the arterial walls.

KEYWORDS: GiD, ABAQUS, FEAP, in-vivo images, IGES, atherosclerosis, angiographies, IVUS.

INTRODUCTION

Nowadays in Spain cadiovascular diseases are the first cause of dead from 75 years old and the second between 15 and 74 years old. This justifies the interest in offering computer assistance for the cardiac diagnostic and therapy. One of the most important research objectives in this field is to assess about the development of atherosclerosis from tridimensional numerical simmulations, based on the calculated hemodynamic representative data (such as pressure, shear stress in the wall, etc.) as well as the mechanical response of the wall, mainly wall stress.

This paper presents the modelling of an arterial wall bifurcation. Geometry data, corresponding to a patient with stenosis was obtained from angiographies and IVUS (IntraVascular Ultrasound System), and imported by GiD (CIMNE, 1999) in IGES format. In the other hand, data about blood pressure and shear stress on the inner surface were calculated with the computer fluid mechanics program FLUENT (Fluent, 2001). The model was analysed by the finite element analysis program for solids ABAQUS (Hibbit et al., 1998), and the results were finally postprocessed with GiD.

In the last part of the paper, it is also presented the way as GiD interfaces with FEAP (Taylor, 2000) using its customization capabilities.

MODELLING OF AN ARTERIAL WALL BIFURCATION

Mesh generation. First of all, an IGES file which define the inner and outer surfaces of the arterial wall was obtained after the analysis of angiographies and IVUS (in-vivo images), (see Fig. 1).

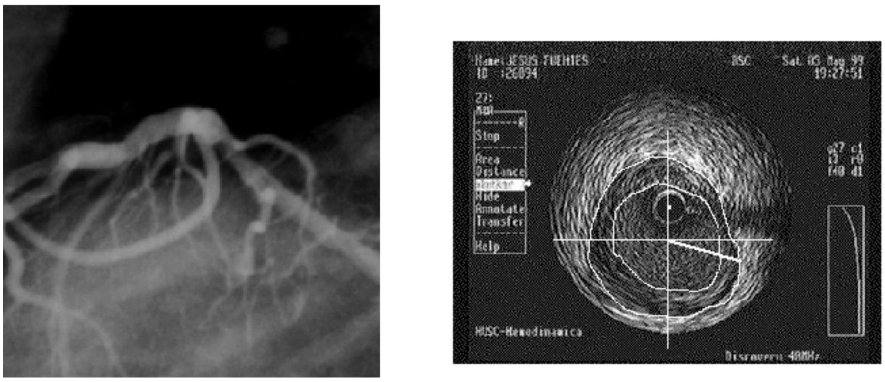

Fig. 1: Images from an angiography (left) and IVUS (right)

The meshing of the surfaces was made using triangular elements. The size of the elements has been determined according to the following criteria:

- It is intended that every element has at least one load point. It has been found out that this requirement is fullfilled with a characteristic element size which is double of the average distance among load points.
- It is necessary to refine the mesh in those places where high gradients of stresses or high variations in the thickness are expected.

Definition of loads and boundary conditions. A semiautomatic calculus has been made based on the files containing the generated mesh and the blood loads previously calculated with FLUENT.In this process both the thickness distribution and the nodal loads of the inner mesh are calculated.

It is supposed that all movements in the upstream and downstream sections are restricted. This is easy to force by creating a nodal set (`*NSET`) with the nodes selected in GiD.

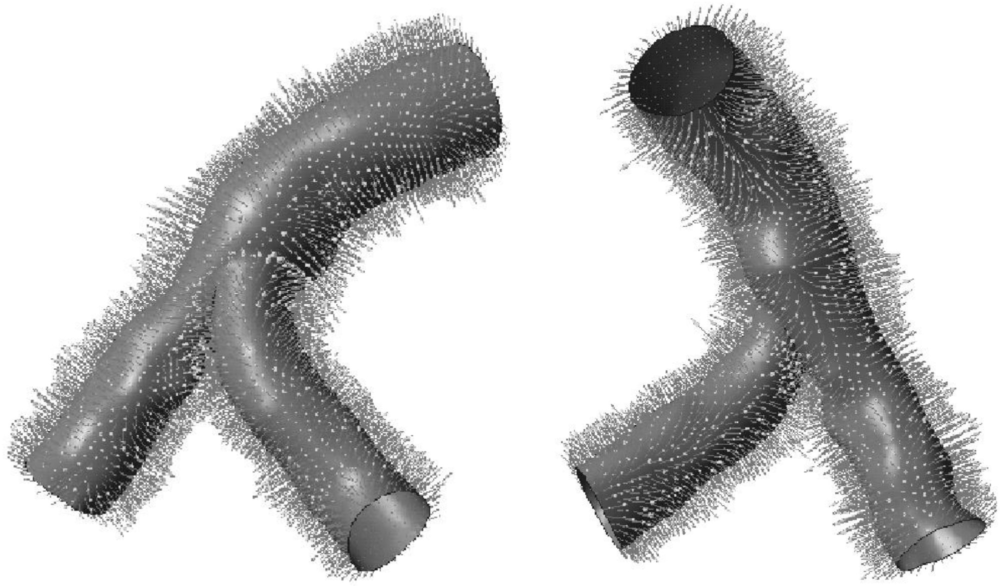

Fig. 2. Nodal forces on the inner wall

Wall stress computation. The model was processed by ABAQUS using triangular elements with three nodes `S3R`, producing a constant interpolation of the membrain and bending strains. Abaqus allows to consider variable element thickness using the option `*NODAL THICKNESS`, where every node can have different thickness. A hyperelelastic quasi-incompressible material (neohookean) was considered in the computation. See for more information (Bonet y Wood, 1997) and (Holzapfel, 2000).

Postprocess. Using GiD, it has been drawn the contour of scalar magnitudes as the pressure on the inner surface, the modulus of shear stress on the inner surface, the thickness of the arterial wall, the Von Mises stress on the inner surface, the Von Mises stress on the outer surface, the medium Von Mises stress in the thickness (Fig. 3) and the homogenity Von Mises stress in the thickness. Also, it was drawn vectorial fields as the shear efforts on the inner surface and the nodal forces on the inner surface (Fig. 2).

INTERFACING GID WITH FEAP

We have developed some configuration files in order to interface GiD and FEAP, in order to export calculation files from FEAP which are directly interpretated by FEAP in 2D and 3D problems. It has been defined:

Global settings. Title, number of load steps, maximum number of iterations, drawing scale, loads and displacements scale.

Materials. Type of materials and a set of mechanical parameters.

Conditions. Nodes and directions where displacements are imposed, displacement and force values. These conditions may be define over points, lines, surfaces and volumes (being this the preferred order). It is also possible to define the entities where nodal displacements (over points) and element stresses (over volumes) are to be controlled.

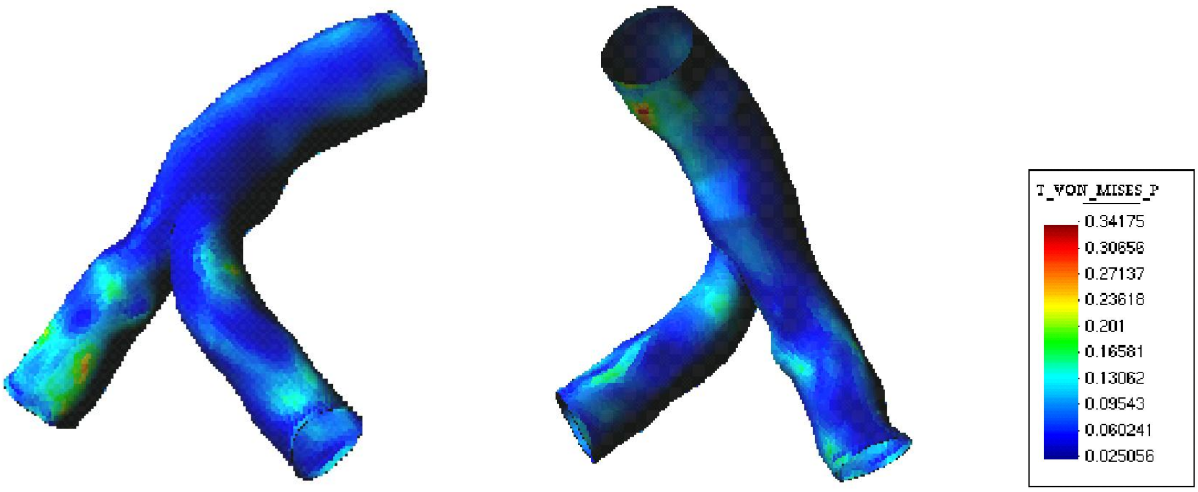

Fig 3. Contours of average Von Mises stress.

CONCLUSIONS

A biomechanics problem calculated by FLUENT and ABAQUS has been presented, and preprocessed and postprocessed by GiD (facilitating the task). In order to perform the analysis, it has been necessary to generate some configuration files for GiD in order to interface with ABAQUS. An interface of GiD with FEAP has also been indicated, making possible the automatic generation of the data file, and minimizing the introduction of mistakes.

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