

Shape-memory alloys: effective 3D modeling, computational aspects and biomedical device analysis

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The employment of shape memory alloys (SMA) in a large number of engineering applications, among which biomedical devices, has been the motivation for an increasing interest toward a correct and exhaustive modeling of SMA macroscopic behavior in order to construct reliable simulation tools, which can be successfully used in the design procedures of SMA devices.

In this work we review a three-dimensional model, giving a good overall description of pseudo-elastic and shape memory behaviors (both in the small-strain [1] and in the finite-strain version [2]), stressing that it is possible to derive not only interesting theoretical considerations (recasting the problem within the framework of the energetic formulation of rate-independent processes and investigating existence and continuous issues at both the constitutive relation and quasistatic evolution level [3]) but also extremely robust solution algorithms [1-2] (see Figure 1).

We exploit such a constitutive and algorithmical framework in the analysis of SMA micro-actuators and biomedical stent devices, focusing the latter analysis on the case of carotid treatments with a novel procedure and investigating the interaction of different stent geometries on specific patient carotid geometries (see Figure 2) [4-5].

References

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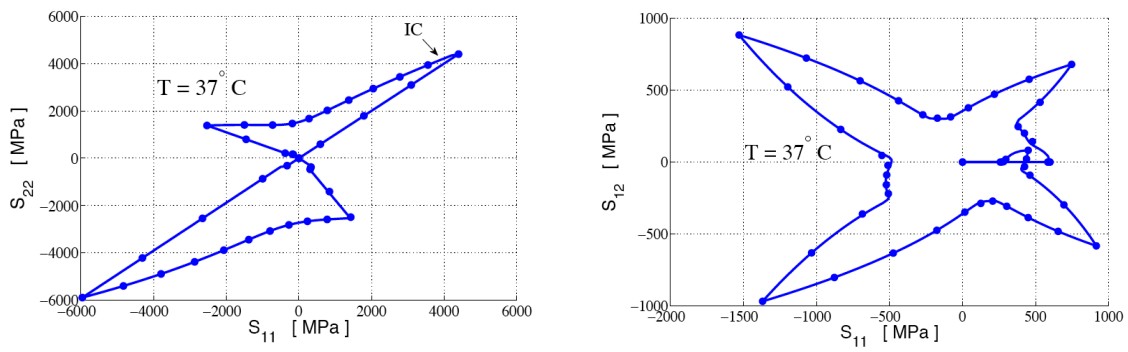


Figure 1: Biaxial (respectively butterfly-shaped and squared-shaped) strain path up to 10% strain at $T = 37^\circ\text{C}$: stress history output for time step size 0.02s (line) and time step size 0.2s (solid circle).

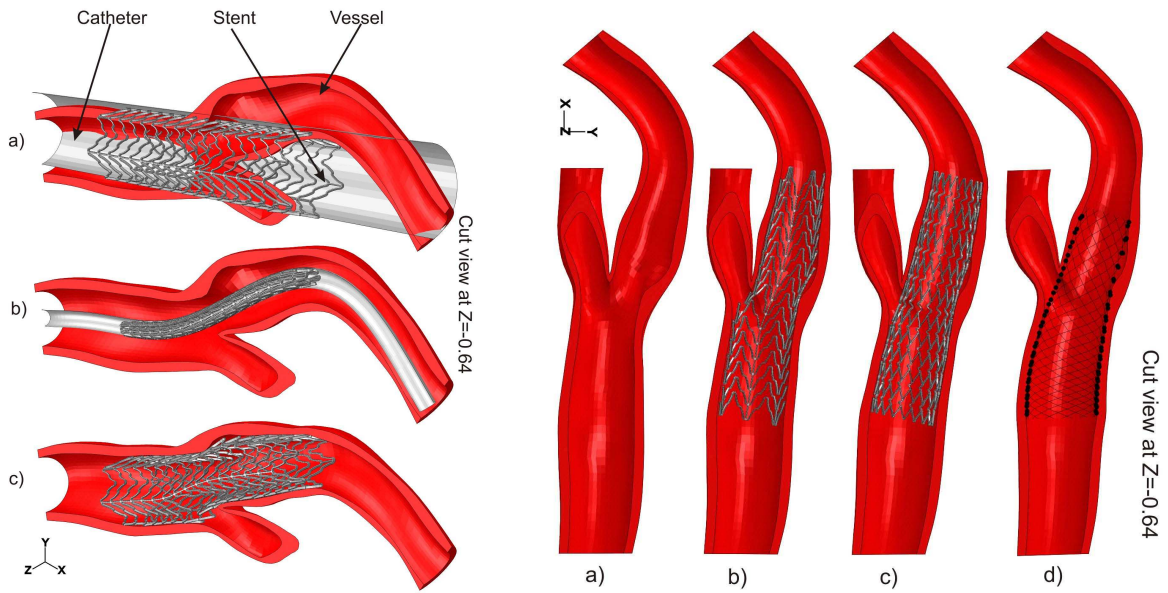


Figure 2: Simulation of the application of a stent to a carotid district and investigation on the effectiveness of different stent geometries on a specific patient carotid geometry.