

## Novel strategy to characterize arterial wall properties including residual strains

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# Novel strategy to characterize arterial wall properties including residual strains

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## Introduction

It is widely recognized that residual strains in arteries reduce circumferential stress ( $\sigma_{\theta\theta}$ ) gradients across the wall at physiological loading conditions [1,2]. A common method to quantify these residual strains is to describe a stress-free geometry with an *opening angle*,  $\alpha$  (fig 1). Major drawbacks of this method are difficulties measuring  $\alpha$  and the stress-free segment not being a perfect circular structure, impairing the proper measurement of  $\alpha$ .

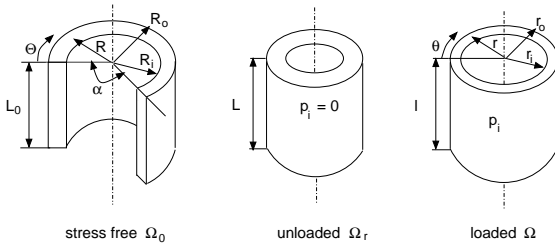


Figure 1: Schematic representation of the opening angle method as a measure for the residual strains

The aim of this study is to investigate whether these experimental problems can be circumvented by incorporating the hypothesis of constant  $\sigma_{\theta\theta}$  at physiological loading conditions into a strategy to estimate the material properties of the arterial wall.

## Methods

The estimation of  $\alpha$  is incorporated into a numerical-experimental scheme, designed to estimate the parameters of a 1D, single layer, vascular tissue model [3].

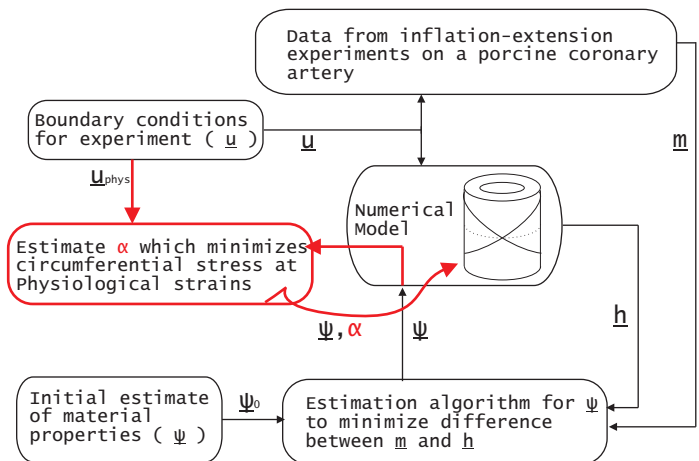


Figure 2: Mixed numerical-experimental method including the estimation procedure for  $\alpha$

## Results

A parameter-set was obtained in which the stress gradients are small at physiological loads (fig 3, top, left) and which describes the pressure-radius relation of the experiments (bottom, left). A measure for the residual stresses, in the unloaded situation, was found (top, right). Furthermore,  $\alpha$  was estimated to be  $242^\circ$  which is close to the value  $220^\circ$  found in the experiment (bottom, right).

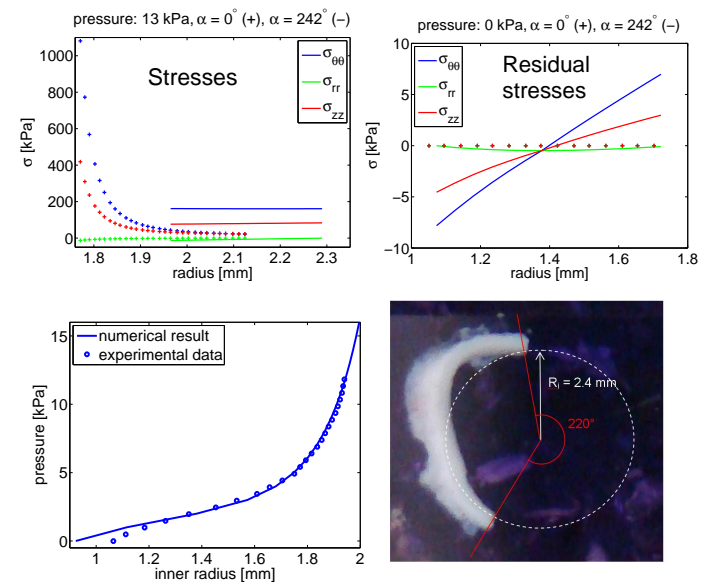


Figure 3: Top: Cauchy stresses with  $\alpha = 242^\circ$  (-) and  $\alpha = 0^\circ$  (+) at physiological loads (left) and in the unloaded situation (right). Bottom: Pressure-radius relation obtained from the experiments and numerical model (left) and a picture showing the opening angle of the artery (right).

## Discussion and conclusions

Although the approach was tested on a single experiment and a relatively simple, 1D, single layer, material model, this study shows the possibility to include a measure for residual stresses by incorporating  $\alpha$ , based on the constant  $\sigma_{\theta\theta}$  hypothesis, into an estimation scheme. This might replace the need for difficult experimental techniques to characterize residual stresses/strains.

## References

- 1 Takamizawa, K., Hayashi, K. (1987) *J Biomech* 20, 7-17.
- 2 Chuong, C.J., Fung, Y.C. (1986) *J Biomech Eng* 108, 703-715.
- 3 Driessen, N.J.B., et al. (2005) *J Biomech Eng* 127, 494-503.