

## Ultrasound elastography of abdominal aortic aneurysms

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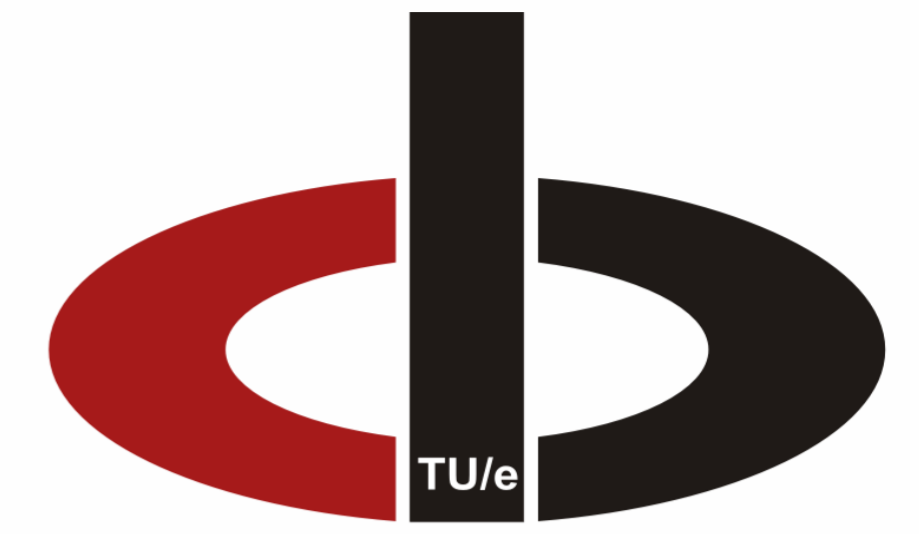
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# Ultrasound Elastography of Abdominal Aortic Aneurysms

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cardiovascular biomechanics

## Aim of our Research

**The aim:** Growth prediction of Abdominal Aortic Aneurysms (AAA) by combining functional ultrasound imaging (US) and patient-specific finite element (FE) modeling.

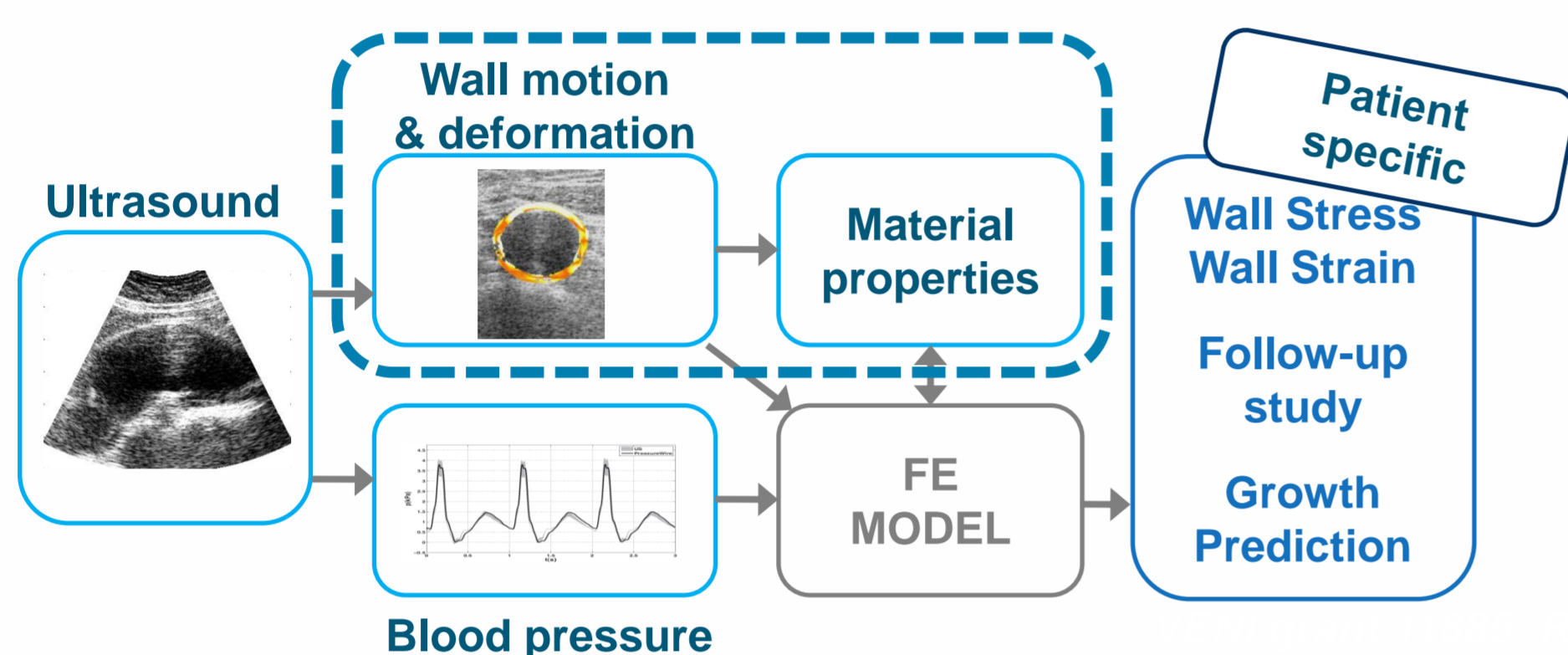


Fig. 1: Towards patient-specific modeling and growth prediction of AAAs using non-invasive ultrasound measurements.

**The first step:** measuring the material properties of healthy and diseased vessels using non-invasive, 2D ultrasound imaging.

## Methods

2D ultrasound imaging (Esaote) was performed in 10 healthy volunteers and 20 AAA patients (I). For five patients, 3D (+t) MRI data were available for comparison (III). The Young's modulus (E) was estimated from the raw US and MRI data. The US data were processed using a 2D tracking algorithm. Volume over time was estimated by assuming axis-rotational symmetry. MRI data were processed with Hemodyn (Philips).

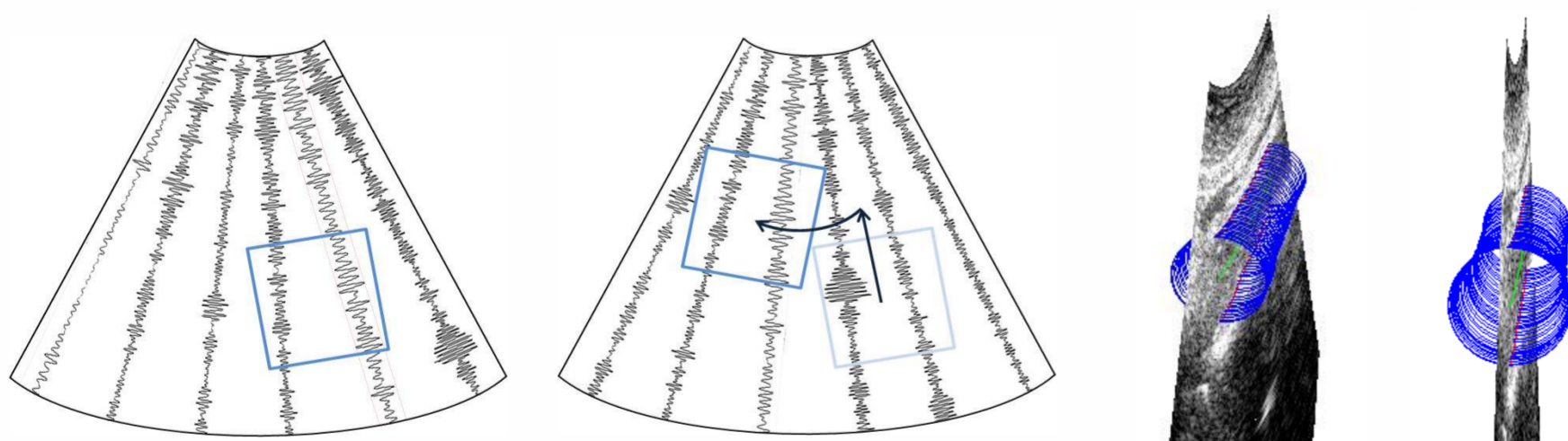


Fig. 2: RF-based 2D displacement estimation (left) and volume estimation using axis-rotational symmetry (right)

In a separate study, 2D and 3D US-data (RF) were acquired in 11 healthy volunteers. Again, the average E was obtained (III) using both 2D and 3D tracking data. Finally, the stress-strain relationship of the aortic wall was assessed using 2D US and finger pressure measurements over the entire cardiac cycle (IV). The E-moduli of elastin and collagen were determined by fitting the slopes at high and low stress.

## Results

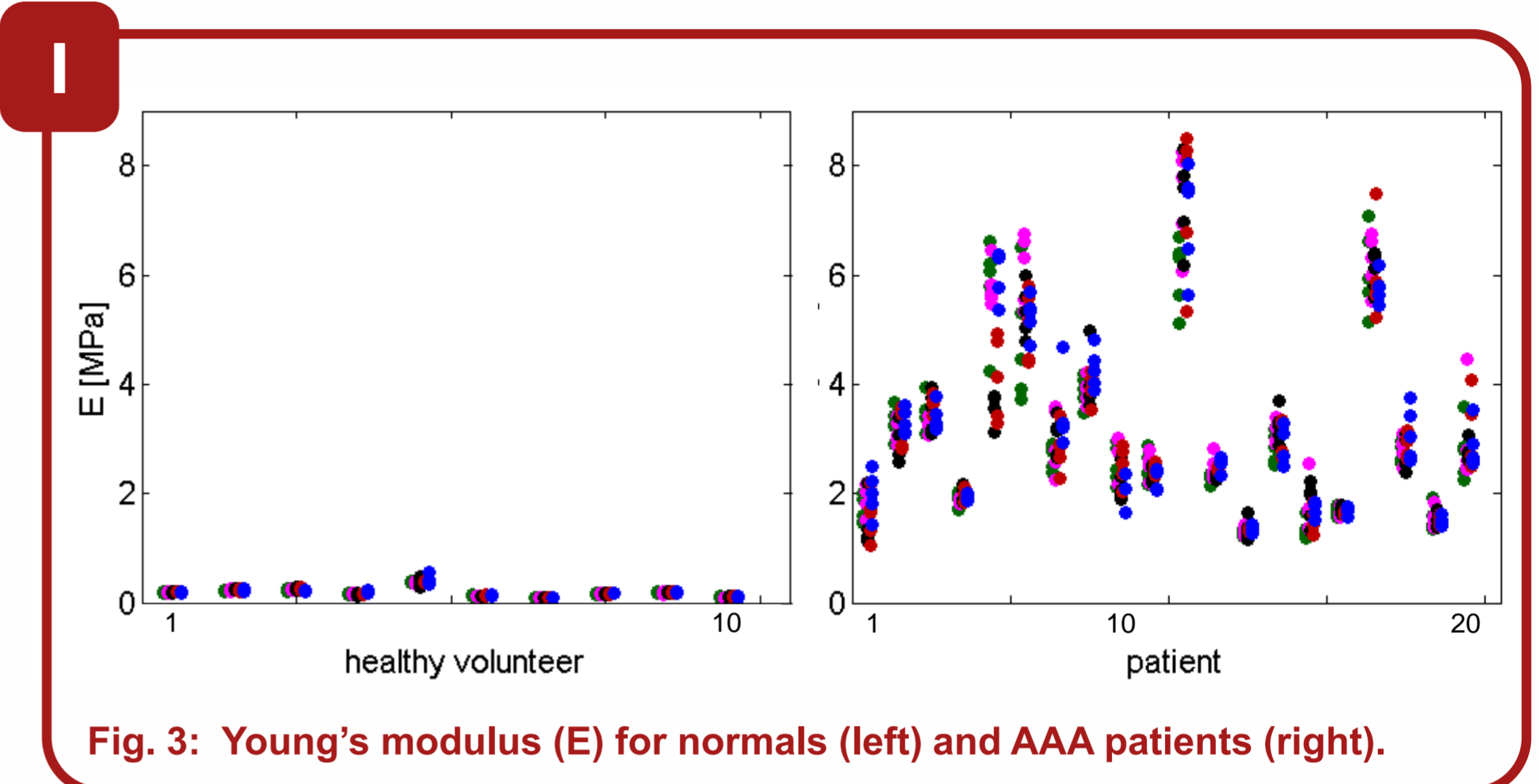


Fig. 3: Young's modulus (E) for normals (left) and AAA patients (right).

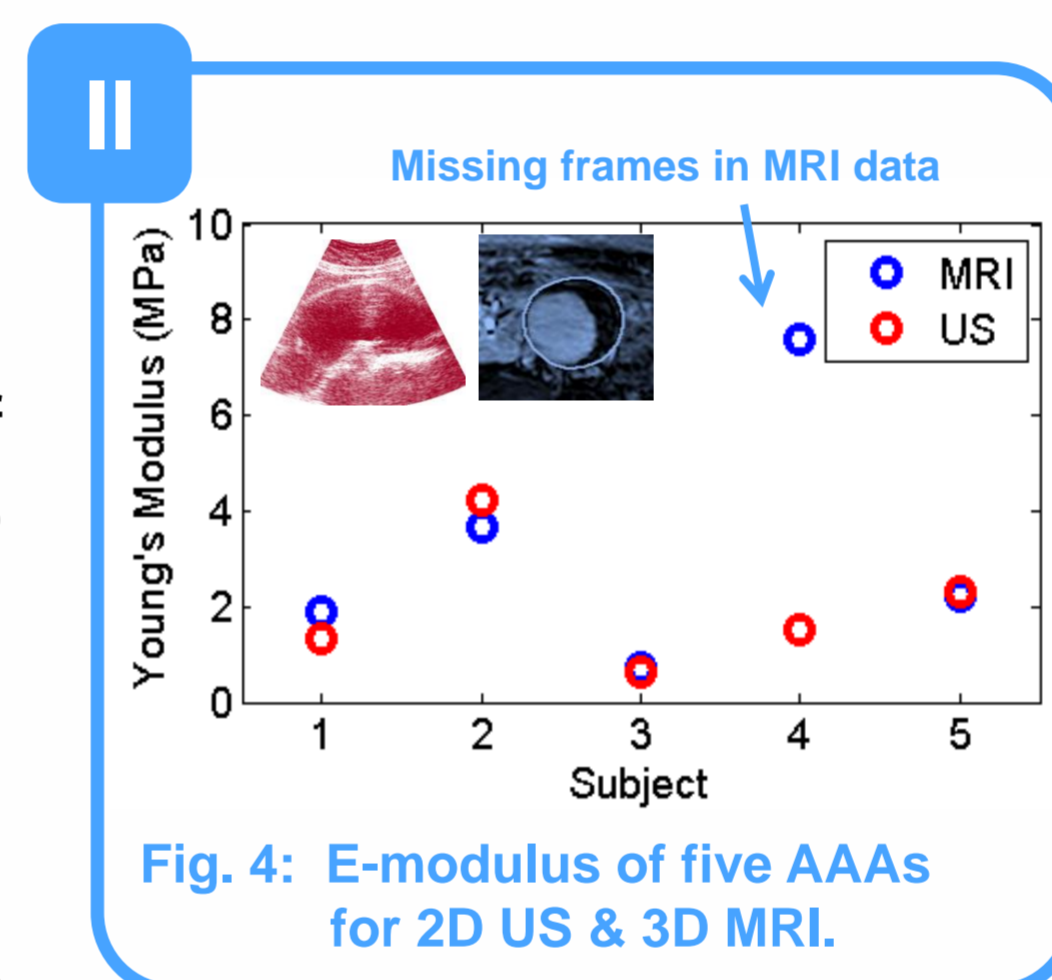


Fig. 4: E-modulus of five AAAs for 2D US & 3D MRI.

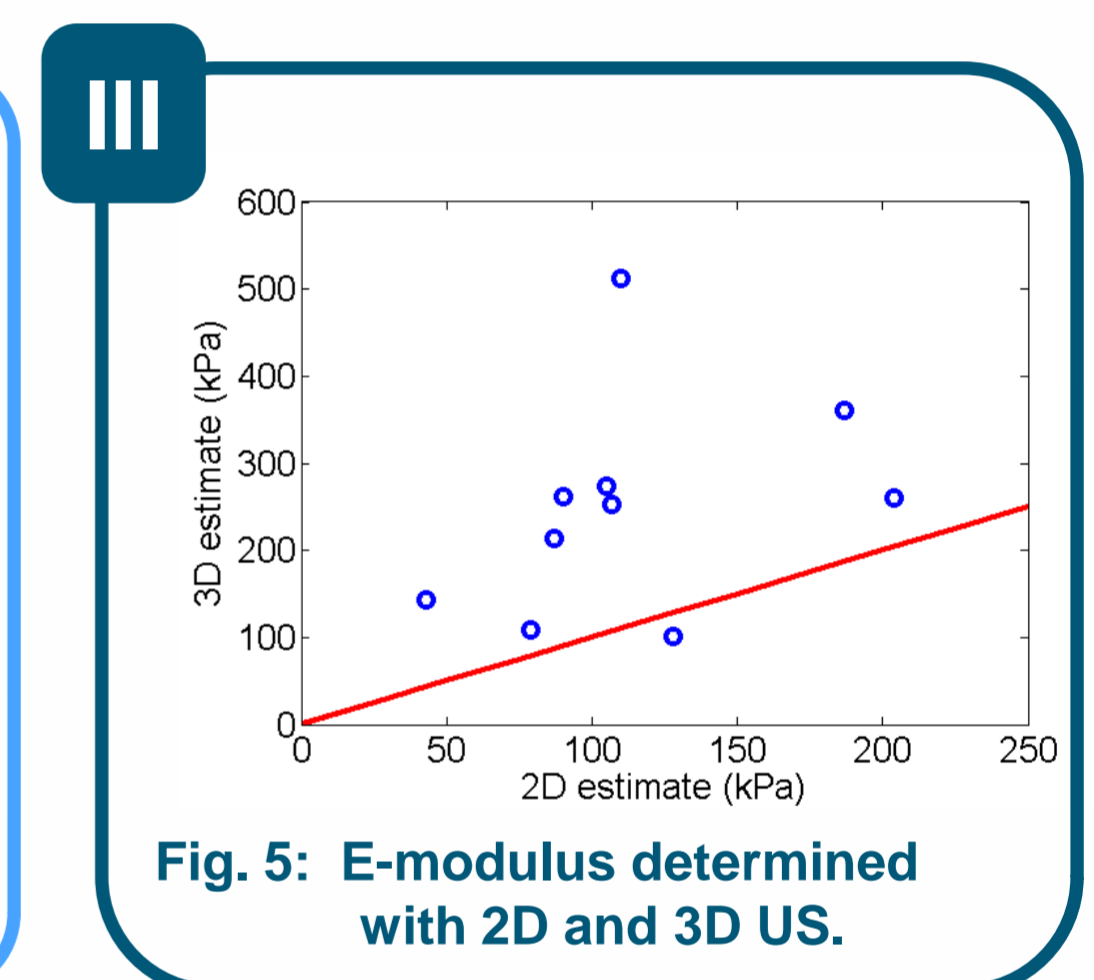


Fig. 5: E-modulus determined with 2D and 3D US.

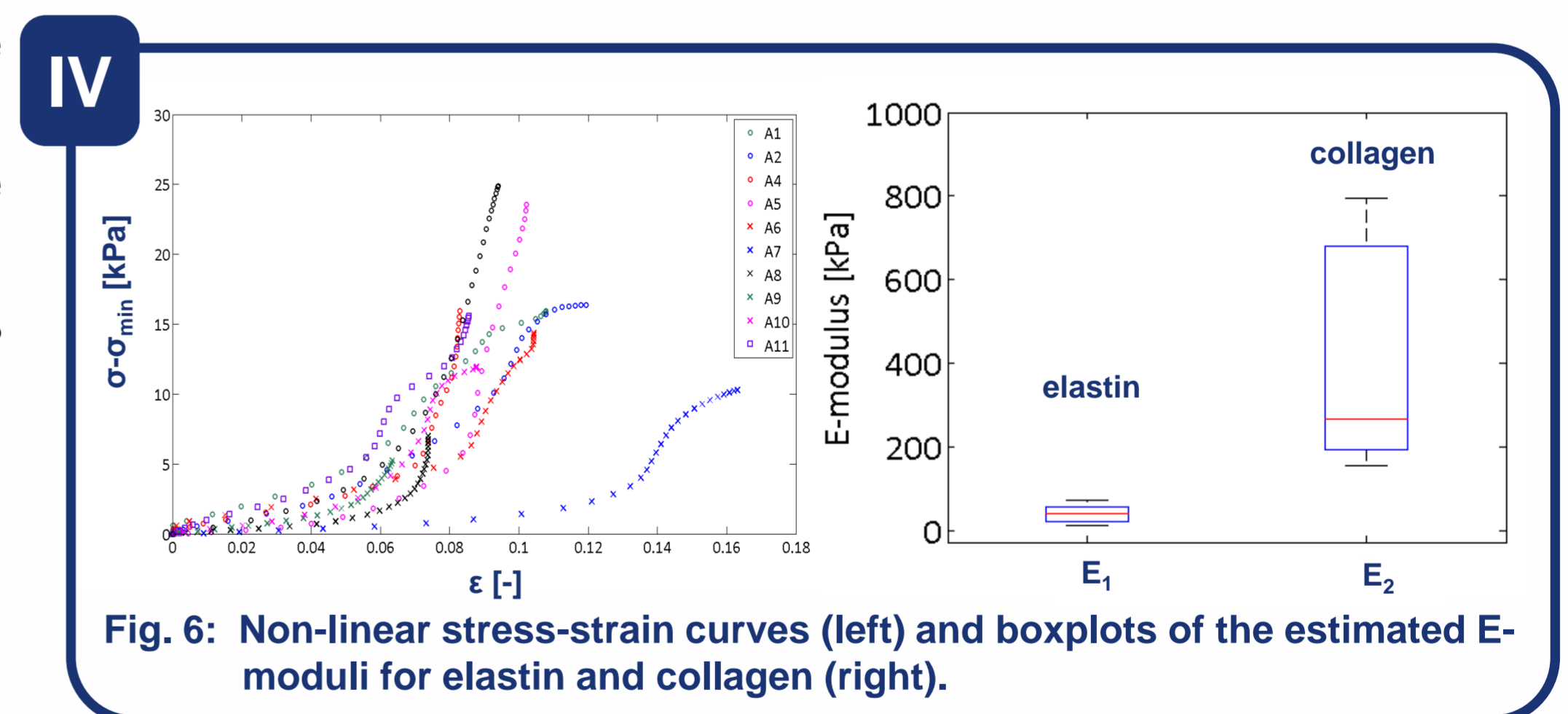


Fig. 6: Non-linear stress-strain curves (left) and boxplots of the estimated E-moduli for elastin and collagen (right).

## Conclusion

Non-invasive assessment of the E-modulus *in vivo* distinguishes patients from normals (I). The 2D US results are in good correspondence with MRI (III) but seem low compared to 3D US (III). A next step will be combining 3D geometry, motion and material properties into patient-specific FE models. Stress-strain measurements yield elastin and collagen properties (IV). The latter might enable growth prediction based on elastin degradation or collagen deposition in the future.