Characterisation of the local mechanical properties of atherosclerotic plaque tissue using an indentation test

Soft Tissue Biomechanics & Engineering

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parisk
a ctmm project

Introduction

- The vulnerable plaque is prone to rupture which can lead to stroke or myocardial infarction.
- Currently, the prediction of this event is based only on geometrical parameters of the plaque.
- Studies indicate that this is insufficient and that also its mechanical properties should be included [1].

Aim

We aim to apply an existing indentation test [2] to measure the local mechanical properties of human plaque tissue.

Slicing of plaque tissue

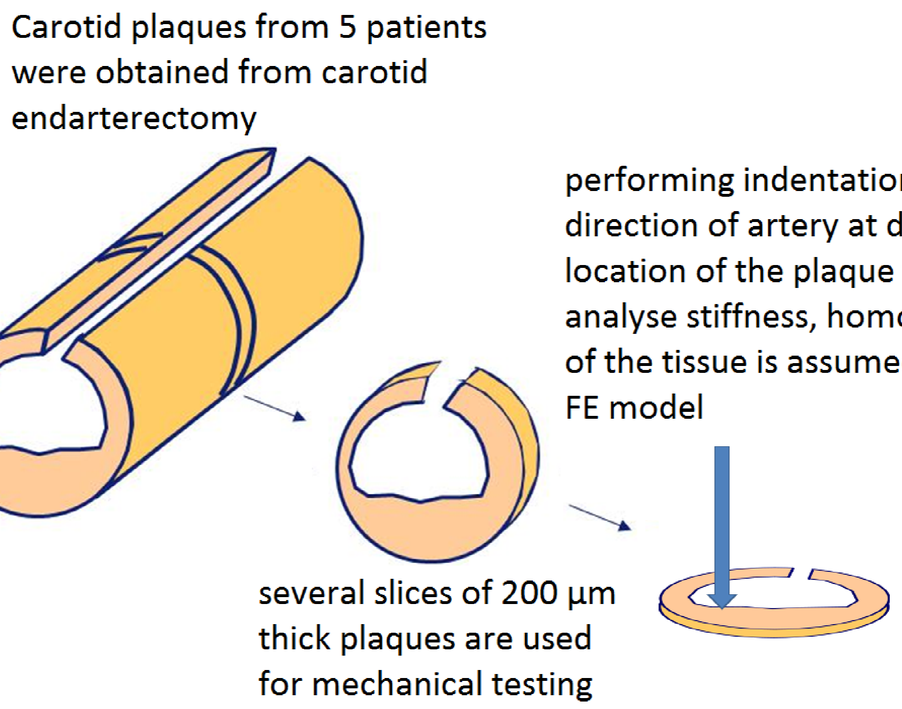
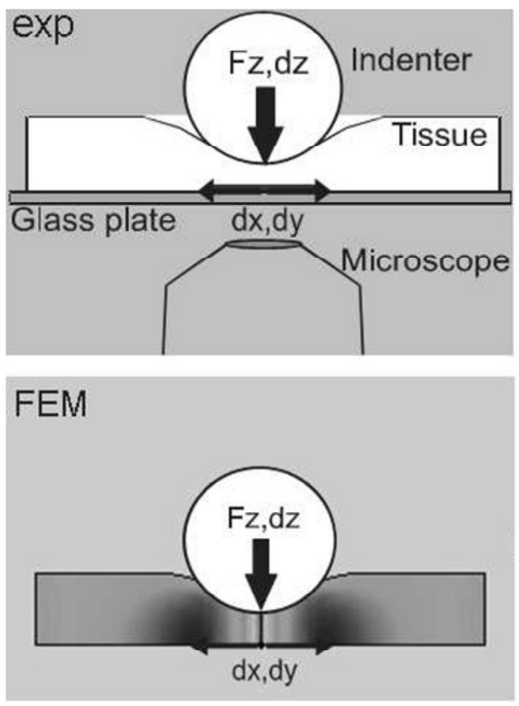


Figure 1 Plaque tissue obtained from endarterectomy were first sliced using a cryotome, depending on the size of the plaque 6 to 11 slices of each plaque were indented in axial direction.

Indentation test



- Spherical indentation (diameter of indenter → 2 mm) combined with confocal imaging and digital image correlation (fig. 2)
- Digital image correlation can be utilised to infer the anisotropic mechanical behaviour in future work
- Finite element inverse analysis to characterise local mechanical properties of plaque tissue [2]

Figure 2 Spherical indenter deforms the underlying tissue, occurring forces are measured, which allows applying the finite element inverse analysis to infer the mechanical properties of the plaque tissue [2].

Stiffness of plaque tissue

- Experiments yielded Young's moduli ranging from 3.8 to 42.8 kPa (fig. 3)
- No significant differences between the chosen locations

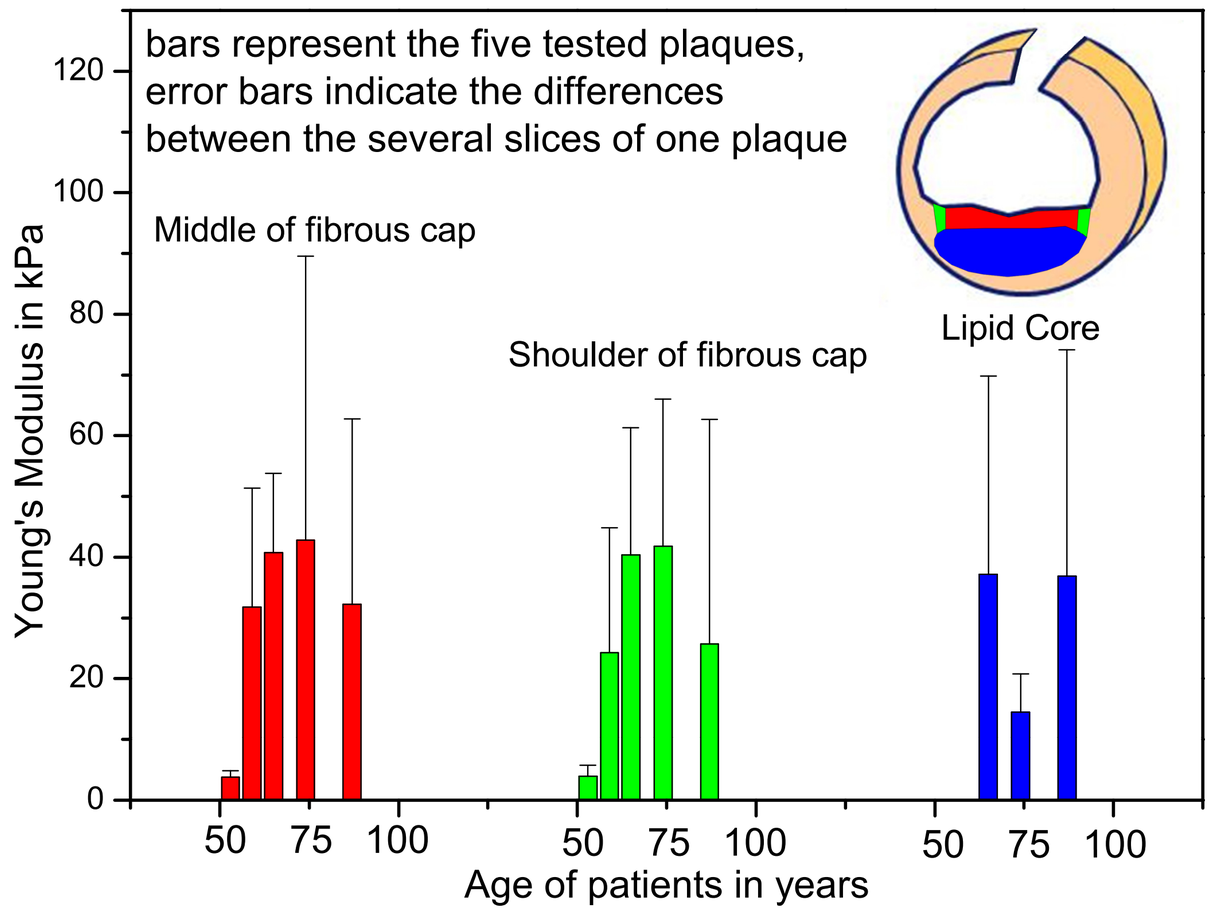


Figure 3 The testing locations were the shoulder regions of the fibrous cap (green), the middle of the cap (red), and the lipid core region (blue).

Discussion

- Literature reveals mean Young's moduli ranging from 33 kPa [3] to 2312 kPa [4], our results correspond to the more recently published data
- Lower values, may be caused by freezing and long storage time
- Our method allows the local measurement of the stiffness of the plaque

Future work

- Measure different plaques in total 10
- Experiments with fresh tissue
- Smaller indenter might allow testing of thin fibrous caps, which are more prone to rupture
- Use the confocal images to conduct digital image correlation to infer the anisotropic behaviour

Acknowledgement

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References
[1] Finet et al. (2004), Coron Artery Dis, 15: 13-20
[2] Cox et al. (2006), J Biomech Eng, 128: 428-435
[3] Barrett et al. (2009) J Biomech, 42: 1650–1655
[4] Loree et al. (1994) J Biomech, 27:195-204