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Local mechanical properties of atherosclerotic plaque tissue

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Introduction and aim

- The major cause of ischemic stroke and myocardial infarction is the rupture of the fibrous cap of vulnerable plaques.
- 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].
- We use an unique in-house developed indentation device [2] to measure the mechanical properties of human plaque tissue.

Slicing of plaque tissue

Carotid plaques from 8 patients are obtained from endarterectomy

Several 0.2 mm thick slices are used for mechanical testing

Indentation test

- Spherical indentation (diameter of indenter is 2 mm) combined with confocal imaging and digital image correlation (fig. 1).
- Indenter deforms the underlying tissue, occurring forces are measured, which allows applying inverse finite element analysis (FEA) to characterise local mechanical properties of plaque tissue.
- Digital image correlation can be utilised to infer the anisotropic mechanical behaviour in future work.

Stiffness of plaque tissue

- Evaluate whether Young’s modulus is different between indentation locations (MidCap, ShCap, Intima, CP) and between tissue types (SC, UC, CP) with Kruskal-Wallis test (Dunn procedure).
- Experiments yielded Young’s moduli ranging from 6 to 890.6 kPa (fig. 2, 3).
- No significant differences could be found between the centre of the cap (MidCap), shoulder (ShCap) of the cap and intima regions (p-value > 0.05, fig. 2).
- Fibrous cap locations and intima regions were significantly stiffer than collagen poor locations (CP, p-value < 0.005, fig. 2).
- No significant differences could be found between dense, structured and loose, unstructured collagen locations (p-value > 0.05, fig. 3).

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

- Experiments with fresh tissue.
- Use the confocal images to conduct digital image correlation to infer the anisotropic behaviour.

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References