MICROMECHANICAL ANALYSIS OF THE EFFECTIVE STIFFNESS OF POROELASTIC COMPOSITES AND ITS APPLICATION TO MYOCARDIAL INFARCTION

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Within this work we investigate the role that the microstructure of a poroelastic material has on the resulting elastic parameters.

We are considering the effect that multiple elastic and fluid phases at the same scale [1] have on the estimation of the materials elastic parameters when compared with a standard poroelastic approach [2].

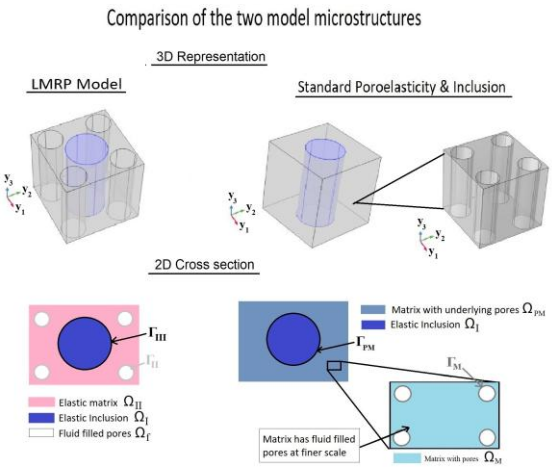

Figure 1: Comparison of the microstructures of both approaches highlighting the direct same scale approach of LMRP and the two-step approach of previous models.

We provide the 3D periodic cell problems with associated boundary loads that are required to be solved to obtain the effective elasticity tensor for both model setups. We then perform a 2D reduction of the cell problems, again presenting the 2D boundary loads that are required to solve the problems numerically.

The results of our numerical simulations show that whenever investigating a poroelastic composite material with porosity exceeding 5% then the model [1] should is better incorporating the structural details in the Young's moduli E_1 and E_3 and the shear C_{44}.

Whenever the porosity exceeds 20% it should also be used to investigate the shear C_{66}. We find that for materials with less than 5% porosity that the voids are so small that a standard poroelastic approach or the model [1] produce the same results.

We investigate how physiologically observed microstructural changes induced by myocardial infarction impact the elastic parameters of the heart [3].

The results of our simulations agree with the physiological observations that can be made post-infarction. That is, the infarcted heart is much stiffer than the healthy heart but with reperfusion of the tissue it begins to soften. We also observe that with the increase in myocyte volume of the non-damaged myocytes the myocardium also begins to soften. With a measurable stiffness parameter the results of our model simulations could predict the range of porosity (reperfusion) that could help return the heart to the healthy stiffness. It would also be possible to predict the volume of the myocytes in the area surrounding the infarct from the overall stiffness measurements.

References

[1].Miller, L, Penta, R. Continuum Mechanics and Thermodynamics, 32, 1533-1557 (2020).

[2] Miller, Laura, and Raimondo Penta. *Biomechanics and Modeling in Mechanobiology* 22, no. 3 (2023): 1019-1033.

[3] Miller, L. and Penta, R., 2023. *European Journal of Mechanics-A/Solids*, *98*, p.104875.

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