Computer Modelling Of Mechanical Response Of Infarcted Heart

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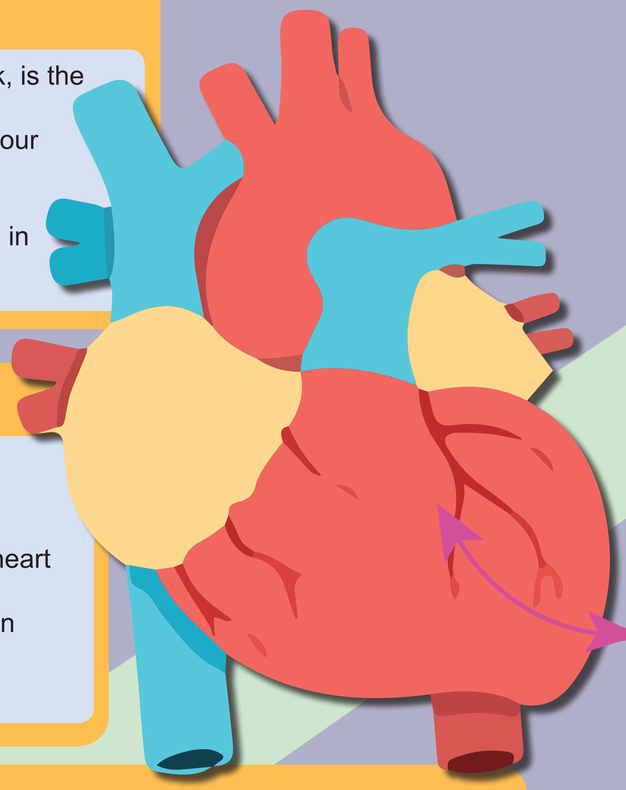
Introduction

Myocardial infarction, also known as heart attack, is the leading cause of mortality worldwide. Gaining a better understanding of the mechanical behaviour of the heart after an infarction may lead to better novel therapies to treat the disease. This study explores the use of hyperelastic material models in Abaqus CAE software.



Objectives

- Carry out a literature review surrounding the heart anatomy and myocardial infarction
- Create accurate FE models.
- Simulate mechanical deformation of infarcted heart during healing proces.
- Generate and present the interpreted simulation results.
- Complete and submit a final report.

Methodology

Create the left ventricle geometry in Abaqus to match given sample data

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Apply a third order Ogden hyperelastic material model to the geometry for all stages of the healing process

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Apply the mesh to the geometry and fix boundary and loading conditions to simulate contraction of the heart

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Run simulations for 5 stages: Healthy, day 2, day 7, day 14, and day 28 post-infarction

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Analyse and compare results

Third order Ogden model

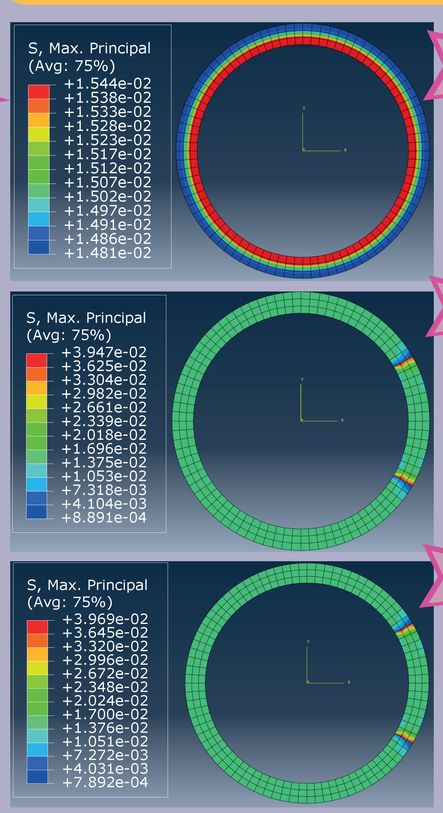
$$W(\lambda_1,\lambda_2,\lambda_3)=\sum_{p=1}^{N}\frac{\mu_p}{\alpha_p}(\lambda_1^{\alpha_p}+\lambda_2^{\alpha_p}+\lambda_3^{\alpha_p}-3)$$

Results

- Primarily focused on isovolumetric phase from end diastole to peak systole pressure, the stress distributions of a slice of the myocardium is shown in the diagrams.
- Distribution of stress and changes in values are dissimilar to experimental data.
- Concentration of stress at the point of material change in the infarcted simulations.

Simulation	Max Principal Stress (MPa)	Max Radial Stress S11 (MPa)	Max Circumferential stress S22 (MPa)
Healthy	0.01544	0.01543	0.00701
Day 2	0.03947	0.03860	0.01820
Day 7	0.03969	0.03880	0.01822
Day 14	0.03980	0.03886	0.01820
Day 28	0.04057	0.03953	0.01671

Summary of results, showing the changes in max stress values at each stage of the healing phase.



Conclusions

- More complex and anisotropic material models may be needed to reproduce more accurate results in future experiments. The third order Ogden isotropic model is limited and does not describe the anisotropic nature of heart tissue.
- Simulations for a 3D model did not prove successful and produced inaccurate values.
- Objectives and deliverables were achieved, however this study forms a foundation that considerable work can be further progressed.

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