Post-infarct Mechanical Behaviour of Rat Myocardial Tissue under Biaxial Tension, Compression and Shear Loads

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INTRODUCTION

The functioning of a heart following a myocardial infarction (MI) is strongly influenced by the mechanics of the infarcted tissue. Understanding the passive mechanical properties of infarcted tissue at different infarct stages is essential for improving the emerging cell delivery treatments for MI.

This study aimed at the mechanical characterization of healthy and infarcted rat myocardial tissue for the development of constitutive models.

METHODS

MI induction: Male Wistar rats (215-280g) underwent experimental infarction by permanent ligation of the left anterior descending coronary artery. Hearts were harvested immediately, 7, 14 and 28 days after MI induction. Sham groups underwent pericardiotomy at similar time points.

Biaxial testing: All tests were performed within 6 hours following harvesting. Specimens (~10x10 mm) were dissected from the anterior wall of the left ventricle subjected to biaxial tensile loading along the cardiac circumferential and longitudinal directions, Figure 1(a). The biaxial stretch was captured by the movement of four optical markers mounted on the epicardial surface of the specimen. Three loading conditions were applied to each specimen: 30:60, 60:30 and 60:60 N/m, respectively. All tests were performed while specimens submerged in 10% phosphate buffered saline at 37°C.

Compression and shear testing: Specimens of infarct groups underwent 30% compression and shear loading (Mach-1, Biosyntech, MN, USA), respectively, following the biaxial testing. Compression test was performed while specimens submerged in 10% phosphate buffered saline at 37°C. Compression was applied at the locations of the four optical markers, Figure 1(b). Shear strain was calculated based on the travel distance of the shear plate and specimen thickness, Figure 1(c).

Histology analysis: Specimens of the 7-, 14- and 28-days infarct groups were sectioned at 8 equidistant planes in cardiac circumferential direction. Slices were stained using Masson's trichrome to identify collagen fibres and imaged using an Eclipse 90i microscope with DXM-1200C digital camera (Nikon Corporation, Tokyo, Japan).Visiopharm Integrator System (Visiopharm, Hørsholm, Denmark) was utilized to measure the infarct areas in each slice using unsupervised image analysis. Specimens with less than 40% infarct area were excluded from the study.

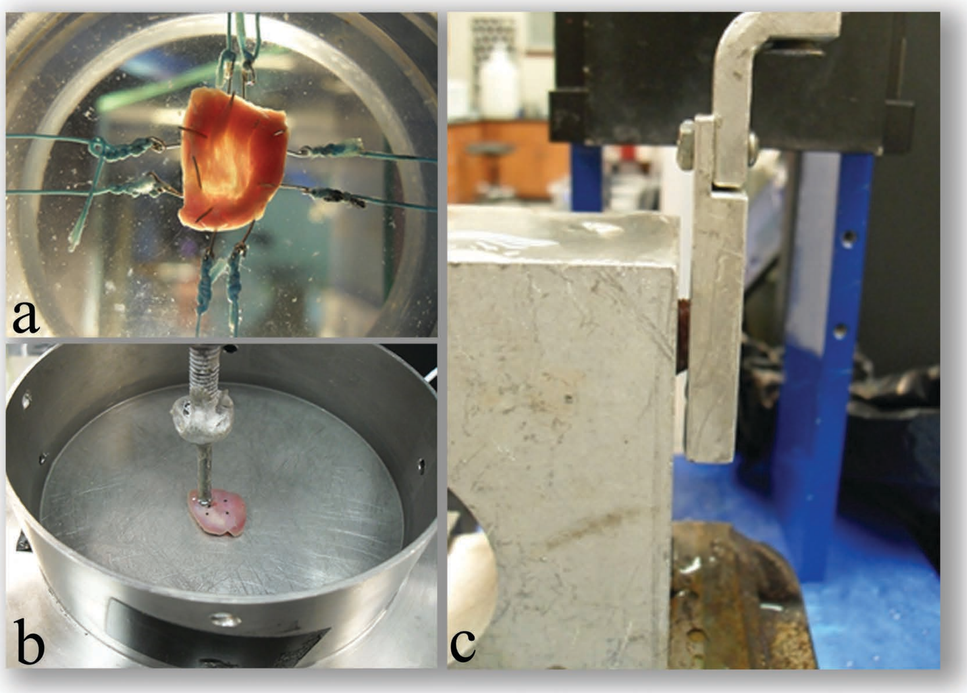

Figure 1: *Specimens underwent three mechanical tests: biaxial (a), compression (b) and shear (c).*

RESULTS

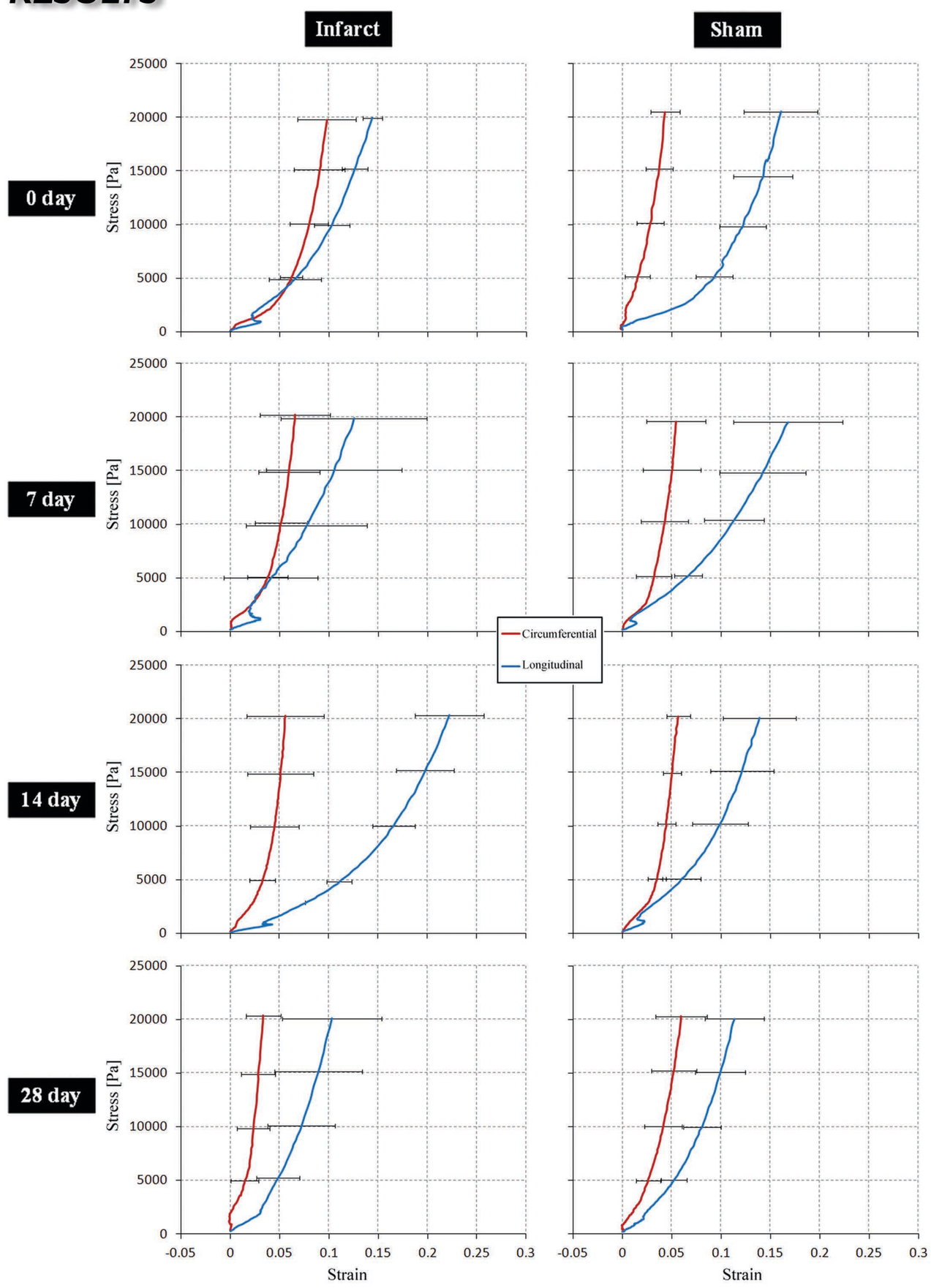

Figure 2: *The biaxial stress-strain curves of infarct and sham groups at different time points.*

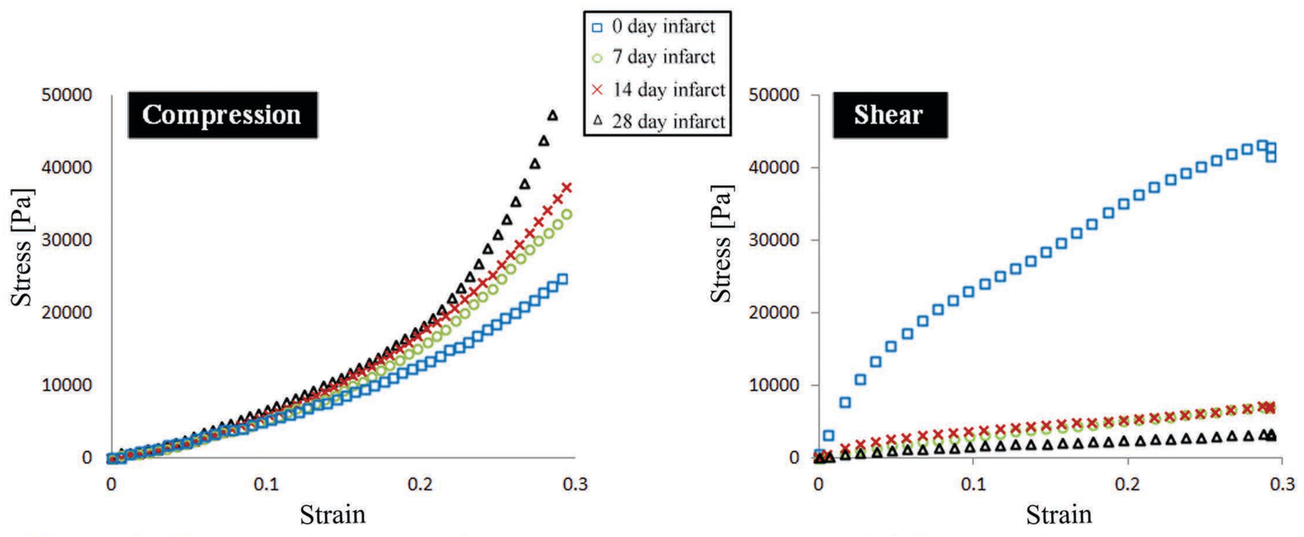

Figure 3: *The compression and shear stress-strain curves of different infarct groups.*

CONCLUSIONS

MI tissue exhibits an increase in stiffness in the circumferential direction with increasing time after infarction. Longitudinally, MI tissue showed the least stiffness at 14 days. Non-infarct (sham) tissue tends to become stiffer with increasing age in the longitudinal direction while becoming softer circumferentially.

Compression stiffness was found to increase with infarct age. Within 2 weeks following MI, shear stiffness considerably drops from ~50 to ~8 kPa.

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