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Research paper

Articular cartilage surface rupture during compression: Investigating the effects of tissue hydration in relation to matrix health

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ARTICLE INFO

Article history:

Received 16 January 2011

Received in revised form

17 April 2011

Accepted 21 April 2011

Published online 29 April 2011

Keywords:

Cartilage

Surface rupture

Osmotic environment

Soft tissue mechanics

ABSTRACT

This study aimed at investigating articular cartilage rupture by investigating the response of healthy and degenerate cartilage through altering the osmotic swelling environment of surface-intact, cartilage-on-bone specimens. The osmotic environment in healthy and degenerate bovine cartilage was varied by soaking tissues in either distilled water or 1.5 M NaCl saline to render the tissues into a swollen or dehydrated state (respectively). Creep compression was applied using an 8 mm flat-ended polished indenter that contained a central pore of 450 μm diameter, providing a consistent region for rupture to occur across all specimens. In the first set of experiments, surface rupture of healthy and degenerate specimens required similar levels of nominal compressive stress (8 MPa) when dehydrated than when swollen (7 MPa). In the second set of experiments, the time required for surface rupture to occur (for healthy and degenerate specimens) occurred over similar loading times ($p > 0.05$). However, the time required for surface rupture for the swollen specimens occurred over a significantly longer time (approximately one order of magnitude) than that required for the dehydrated specimens ($p < 0.05$). The compressive strains that were measured at rupture in the dehydrated degenerate specimens were significantly lower than those measured in the dehydrated healthy tissues ($p < 0.05$). Rupture in dehydrated degenerate cartilage suggested a weakened articular surface, and it also suggested that dehydrated cartilage may undergo failure due to stress concentrations as it is unable to redistribute stress away from the site of loading.

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1. Introduction

This paper compares surface rupture between healthy and mildly degenerate articular cartilage samples under different states of tissue hydration. The effects of tissue hydration on

surface rupture have also been compared. Articular cartilage surface rupture occurs during degeneration (Weightman et al., 1973). It has been investigated in terms of understanding crack generation, propagation (Flachsmann et al., 2001), and how reducing the tissue fluid reduces its vulnerability to

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doi:10.1016/j.jmbbm.2011.04.018