Nanoindentation Technique Approach to Predict the Surface-Coating Endurance on Articular Cartilage

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ABSTRACT

In the case of surface-coatings application, it is crucial to establish when the substrate is reached to prevent catastrophic consequences. Nevertheless, some studies of surface coating have been explained by a coating phenomenon observed below a critical residual coating thickness. The objective of this study was to test the frictional response of the coated articular cartilage to interstitial fluid pressurization which accounts for the osmotic pressure in cartilage by using indentation under dynamic loading. In this study, a model was based on the theory of mixtures for soft hydrated charged tissues, local dissipated energy and related to the friction process under the action of an applied cyclical stress in confined compression over a range of loading frequencies. The experimental results demonstrated that pressurization does take place with increasing loading frequency, concurrently with a decrease in tissue compliance. Therefore, the cartilage dynamic stiffness can be demonstrated experimentally the significance of cartilage deformation as the mechanism of cartilage load support over a wide range of frequency.

Key words: Nanoindentation, Articular cartilage, Surface coating

INTRODUCTION

Articular cartilage is a hydrated soft tissue which serves as the bearing material of diarthrodial joints. It is often highly anisotropic elastically and this needs to be taken into account when analyzing experimental results in elastic properties. The mechanical response of cartilage has been investigated in many studies and it is generally accepted that its viscoelastic response is primarily contributed by the resistive drag of interstitial fluid flowing through the low-permeability collagen-proteoglycan matrix. So the porous structure models have been proposed which describe this mechanical response under various loading conditions and contributes to the load support across the tissue (Gray et al., 1988; Ateshian et al., 1998).

At the same time, theoretical porous media analyses have demonstrated that fluid pressurization contributed to supporting upwards of 90% of the applied stress during contact of cartilage layers (Mow et al., 1980; Fridrici et al., 2003). These studies have suggested that loading situations where contact tractions can be typically as high as 12 MPa, the fluid pressure could act to shield the solid matrix of collagen by maintaining the effective collagen