Original Article

Quantitative Evaluation of Equine Articular Cartilage Using Cationic Contrast-Enhanced Computed Tomography

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Abstract

Objective. To investigate the diffusion trajectory of a cationic contrast medium (CA4+) into equine articular cartilage, and to assess normal and degenerative equine articular cartilage using cationic contrast-enhanced computed tomography (CECT). *Design*. In the first experiment (Exp1), equine osteochondral specimens were serially imaged with cationic CECT to establish the diffusion time constant and time to reach equilibrium in healthy articular cartilage. In a separate experiment (Exp2), articular cartilage defects were created on the femoral trochlea (defect joint) in a juvenile horse, while the opposite joint was a sham-operated control. After 7 weeks, osteochondral biopsies were collected throughout the articular surfaces of both joints. Biopsies were analyzed for cationic CECT attenuation, glycosaminoglycan (GAG) content, mechanical stiffness (E_{eq}), and histology. Imaging, biochemical and mechanical data were compared between defect and control joints. *Results*. Exp1: The mean diffusion time constant was longer for medial condyle cartilage (3.05 $\pm$ 0.1 hours) than lateral condyle cartilage (1.54 $\pm$ 0.3 hours, $P = 0.04$). Exp2: Cationic CECT attenuation was lower in the defect joint than the control joint ($P = 0.005$) and also varied by anatomic location ($P = 0.045$). Mean cationic CECT attenuation from the lateral trochlear ridge was lower in the defect joint than in the control joint (2223 $\pm$ 329 HU and 2667 $\pm$ 540 HU, respectively; $P = 0.02$). Cationic CECT attenuation was strongly correlated with both GAG ($\rho = 0.79$, $P < 0.0001$) and E_{eq} ($\rho = 0.61$, $P < 0.0001$). *Conclusions*. The equilibration time of CA4+ into equine articular cartilage is affected by tissue volume. Quantitative cationic CECT imaging reflects the biochemical, biomechanical and histological state of normal and degenerative equine articular cartilage.

Keywords

horse, osteoarthritis, contrast agent, computed tomography arthrography (CTa), imaging

Introduction

Detection of early articular cartilage injury is a substantial problem in humans and horses. Early cartilage degeneration begins with changes in the extracellular matrix, particularly the loss of glycosaminoglycans (GAGs).[1] In normal (healthy) articular cartilage, the negative charges on GAGs attract water, maintaining tissue hydration and affording compressive stiffness.[2] Conversely, the depletion of GAGs reduces water retention and weakens the tissue, promoting articular cartilage deterioration. Despite its status as a gold standard method of articular cartilage evaluation, routine magnetic resonance imaging (MRI) techniques only capture morphologic changes and are incapable of characterizing the early biochemical alterations in GAGs that precede morphologic change.[3,4] This limitation has led to the development of quantitative MRI techniques to identify early degenerative changes in articular cartilage.[5-7] Delayed gadolinium-enhanced MRI of cartilage (dGEMRIC) is one example of a quantitative

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