



Assessment of healthy trapeziometacarpal cartilage properties using indentation testing and contrast-enhanced computed tomography

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ABSTRACT

Background: The trapeziometacarpal joint is a common site for osteoarthritis development in the hand. When osteoarthritis is present, it results in significant functional disabilities due to the broad range of activities performed by this joint. However, our understanding of osteoarthritis initiation and progression at this joint is limited because of the current lack of knowledge regarding the properties and structure of the corresponding cartilage layers. The objective of this study is to assess the morphological and mechanical properties of trapeziometacarpal cartilage via the combination of indentation testing and contrast-enhanced computed tomography. Such research may lead to the development of medical imaging-based approaches to measure cartilage properties in vivo.

Methods: Intact first metacarpals and trapezia were extracted from 16 fresh-frozen human cadaver hands. For each specimen, load-displacement behavior was measured at 9 testing sites using a standardized indentation testing device to calculate the normal force and Young's modulus of the cartilage sub-regions. The specimens were then immersed in CA4+ contrast agent solution for 48 h and subsequently scanned with a resolution of 41 μm in a HR-pQCT scanner to measure cartilage thickness and attenuation. Finally, correlations between compressive Young's modulus and contrast-enhanced computed tomography attenuation of the cartilage were assessed.

Findings: No significant difference was found in cartilage thickness between the trapezium and first metacarpal, but the comparison between articular regions showed thinner cartilage around the volar aspect of both the first metacarpal and the trapezium. The first metacarpal cartilage was stiffer than the trapezial cartilage. A significant positive correlation was observed between Young's modulus and mean contrast-enhanced CT attenuations in superficial and full-depth cartilage in both the first metacarpal and the trapezium cartilage.

Interpretation: The quantitative measurements of trapeziometacarpal thickness and stiffness as well as a correlation between Young's modulus and contrast-enhanced computed tomography attenuation provides a method for the non-destructive in vivo assessment of cartilage properties, a greater understanding of thumb cartilage behavior, and a dataset for the development of more accurate computer models.

1. Introduction

Osteoarthritis (OA) is one of the most prevalent joint diseases and

represents a leading cause of disability for millions of people around the globe (Cisternas et al., 2016; Royal College of Physicians, 2008). OA is multifactorial condition that can originate from a diversity of factors,

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