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## Technical note

# The use of polyacrylamide gels for mechanical calibration of cartilage — A combined nanoindentation and unconfined compression study

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## ABSTRACT

This study investigates polyacrylamide (PA) gel as a calibration material to measure the nanomechanical compressive modulus of cartilage using nanoindentation. Both nanoindentation and unconfined compression testing were performed on PA gel and porcine rib cartilage. The equilibrium moduli measured by the two methods were discernable. Nanoindentation has the advantage of distinguishing between spatially dependent constituent properties that affect tissue mechanical function in heterogeneous and hierarchically structured tissues such as cartilage. Both sets of measurements exhibited similar positive correlation with increasing gel crosslinker concentration. The compressive modulus measurements from compression in the PA gels ranged from 300 kPa–1.4 MPa, whereas those from nanoindentation ranged from 100 kPa–1.1 MPa. Using this data, a method for relating nanoindentation measurements to conventional mechanical property measurements is presented for porcine rib cartilage. It is shown that based on this relationship, the local tissue modulus as measured from nanoindentation (1.1–1.4 MPa) was able to predict the overall global modulus of the same sample of rib cartilage (2.2 MPa), as confirmed by experimental measurements from unconfined compression. This study supports the use of nanoindentation for the local characterization of cartilage tissues and may be applied to other soft tissues and constructs.

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## 1. Introduction

The complex structures and heterogeneity of cartilage presents challenges to characterizing its material properties. Commonly employed mechanical tests, such as confined

and unconfined compression, at best treat the tissue as a poroelastic, multi-phasic, isotropic material (Armstrong and Mow, 1982; Athanasiou et al., 1994; Kempson et al., 1971; Sokoloff, 1966; Hayes and Mockros, 1971). These methods give information about the global behavior of the tissue as

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