EVALUATION OF OSMOSIS-INDUCED DEFORMATION OF ARTICULAR CARTILAGE USING ULTRASOUND BIOMICROSCOPY IMAGING

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INTRODUCTION

Articular cartilage, a biological connective tissue, covers the bony ends of articulating joints. It has been found that the unique composition and multilayered structure of articular cartilage contribute to its intrinsic biomechanical properties.

In recent years, ultrasound has been utilized to measure not only the acoustic properties but also the mechanical properties of cartilage combined with compression and indentation methods. This study introduced an ultrasound biomicroscopy imaging method to evaluate the osmosis-induced deformation of artilage cartilage and its mechanical properties.

METHODS

The ultrasound biomicroscopy system consisted of a computer-controlled stepper-motor, 3-D translating device and the signal acquirement system (Figure 1). Ultrasound transducer could be moved vertically and horizontally in the *x*, *y* and *z* directions to obtain the maximum echoes from the tissue. Using the custom-made software, the digitalized A-mode ultrasound signals and B-mode images were stored for the offline analysis.

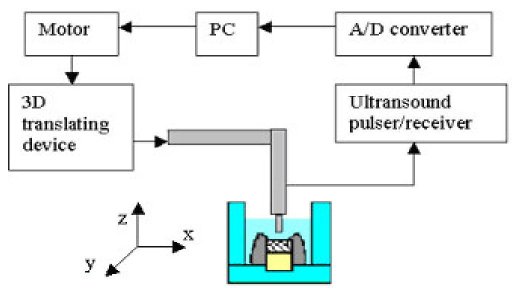
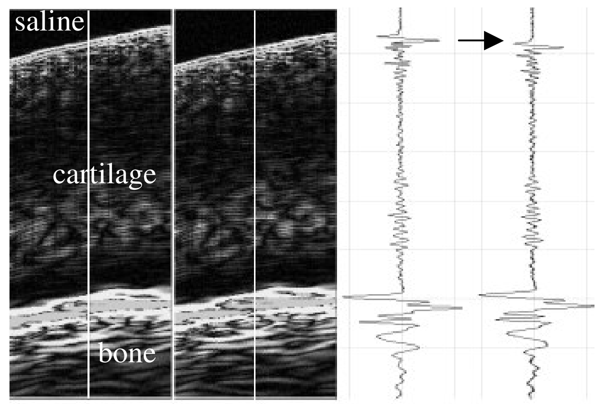


Figure 1: Schematic of the ultrasound system.

Cartilage-bone plugs (n = 5) with a diameter of 6.35 mm and the cartilage thickness ranged from 1.39 mm to 1.70 mm were prepared from the proximal-lateral side of bovine patellae. Specimen was fixed on the bottom of the container and equilibrated for one hour in physiological saline solution (0.15 M NaCl), and then the solution was immediately replaced by the hypertonic saline (2 M NaCl). The deformation of cartilage under the osmotic loading was monitored by the ultrasound biomicroscopy imaging system.

RESULTS AND DISCUSSION

The section (full-thickness of cartilage × 1.5mm) of the central portion of specimen was scanned (Figure 2). From the deformation of cartilage specimens under the osmotic loading due to the increase of the concentration of the external saline bath, the compressive strains were measured from 0.003 to 0.025 for the five samples. The mean ultrasound speeds in 2 M saline and in cartilage immerged in 0.15 M saline were 1646 m/s and 1652 m/s, respectively, measured using a noncontact method reported earlier [1].



(a) (b) (c) (d)

Figure 2: B-mode ultrasound images of one specimen equilibrated (a) in physiological saline and (b) in hypertonic saline. Ultrasound beam propagated along the thickness direction. The grey levels of the image linearly represent the amplitudes of the RF signals. RF signals in (c) and (d) correspond to the positions indicated by the white solid lines in (a) and (b), respectively. The black arrow indicated that the echoes reflected from cartilage surface shifted slightly due to the alteration of the saline concentration.

Swelling behavior is thought to be important for the overall mechanical properties and functions of cartilage and provides a high resistance to compressive loads. Most of previous studies reported the swelling-induced strains of cartilage, but not along a cross-section *in situ* [2-4]. The present study investigated the transient response of cartilage to the osmotic loading *in situ*. The results showed that the ultrasound biomicroscopy scanning technique could be feasible to assess the fine deformation of cartilage of both large and small animals.

CONCLUSIONS

In comparison with traditional mechanical methods and optical methods, this method is potential to be applied for *in-vivo* applications due to the capacity of recording the transient deformation of the intact tissue nondestructively.

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