

Letter

Ultrasound has the potential to detect degeneration of articular cartilage clinically, even if the information is obtained from an indirect measurement of intrinsic physical characteristics

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We appreciate the concern shown by Zheng and Huang [1] regarding our earlier article [2]. We presented simple data showing that the ultrasound response of articular cartilage may be related to its International Cartilage Repair Society grading, and concluded that ultrasound evaluation using the signal intensity – dependent on the ultrasound reflection coefficient at the cartilage surface – may be helpful to differentiate International Cartilage Repair Society grades, especially grade 0 from grade 1 cartilage [2].

Our ultrasound system obtains indirect information on intrinsic physical characteristics of living human articular cartilage *in vivo*. We recognize that the ultrasound signal intensity of articular cartilage relates to the parameters of the tissue reflection coefficient, acoustic impedance, the elastic modulus, and surface conditions. In clinical settings, however, these parameters are difficult to measure separately. We therefore consider that the signal intensity obtains information including these parameters.

We do not disregard measuring the intrinsic physical characteristics. Indeed, the signal intensity (maximum magnitude) correlated significantly with the aggregate modulus of articular cartilage [3]. We mentioned the equations of Young modulus, indicating the speed of sound, the density of a material, and the acoustic impedance of a material [4], and presented the Gabor function as the mother wavelet and equations [2]. The signal intensity did not depend on the surface curvature for radii >40 mm, and mainly reflects the condition from the surface of the cartilage to a depth of one

wavelength (about 0.150 mm) [5]. The tip of the probe with an ultrasonic transducer is designed to achieve uniform distance between the transducer and the cartilage surface.

Our ultimate goal is not to measure the intrinsic physical characteristics but to improve the diagnostic use of an arthroscopic ultrasound system and the method to detect the early stage of degeneration of human articular cartilage. The signal intensity, considering tissue histology [4] and estimation of the mechanical property of meniscus [6], was studied aiming toward human clinical study [7]. Our ultrasound system can be used with the arthroscopic probe and can obtain information on the degeneration of human articular cartilage *in vivo*.

It is not easy to calculate the intrinsic physical characteristics from an ultrasonic echo obtained under arthroscopy. True it is ideal that the intrinsic physical characteristics of cartilage are measured accurately, but this is still difficult in clinical settings using existing devices. The authors consider that weakness to measure the intrinsic physical characteristics accurately does not interfere with our final purpose; that is, quantitative evaluation of human cartilage in clinical settings such as arthroscopy.

Finally, information on the signal intensity is valuable for clinicians who want to know the mechanism of degeneration of cartilage without performing a tissue biopsy. Until an ultrasound system that can measure the intrinsic physical characteristics of human cartilage *in vivo* is developed, we believe

that the ultrasound information our technique provides will help clinicians to understand degeneration of articular cartilage – even if the information is obtained from an indirect measurement of the intrinsic physical characteristics.

Competing interests

The authors declare that they have no competing interests.

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