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Analysis of Acoustic Characteristics in Cartilage and Meniscus Diseases
軟骨および半月板疾患における音響特性解析

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1. Introduction

Currently, the diagnosis of the knee joint carried out with X-ray radiography, MRI, and ultrasonic diagnostic equipment. However, a quantitative evaluation for the progress of diseases is difficult. In addition, visual diagnosis by ultrasound which performed for meniscus and cartilage is also difficult, because the relationship between the information obtained from the echo signal and the composition and/or structure of the tissue has not been fully elucidated. The other diagnostic method is an arthroscopic inspection using an endoscope. But it is not suitable to perform the repetitive inspection, so the establishment of quantitative diagnostic methods noninvasive is demanded in clinical practice.

In order to investigate the relationship between the acoustic characteristics and the tissue properties of meniscus and cartilage, we focus on the speed of sound and the attenuation which are the main factor in determining the characteristics of the echo signal. Then, we analyzed them in cartilage and meniscus using the bioacoustic microscopy. The target tissues are the cartilages and the meniscus of rabbits.

2. Bioacoustic microscopy

The acoustic characteristics were measured by a Bioacoustic microscopy system (modified AMS-50SI , Honda Electronics) with 80 MHz center frequency transducer (Toray Engineering). Figure 1 shows an example image of measurement. This system can measure the speed of sound, the attenuation and the thickness of tissue. The measurement objects are10 μm thickness specimens. The specimens were measured by placing the tissue that cut it in the thickness of 10 μm on the glass plate. The undyed 10 μm pathology specimens were used for the measurment of acouttic characteristics by the bioacoustic microscopy. To examine the measurement result, the 4 μm pathology specimens were stained with the Safranin-O stain.

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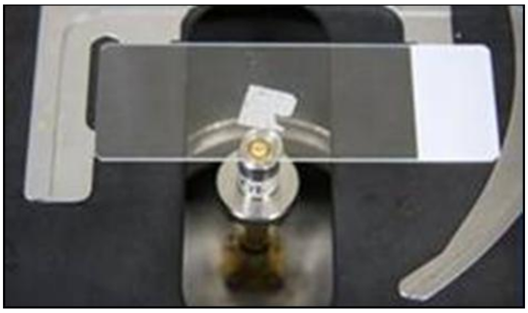

Fig. 1 Measurement image

3. Measurement object

We prepared cartilage degeneration rabbits from 4 male New Zealand white rabbit. 1 feather was injected saline into knee joint, 3 feathers were injected collagenase TYPE-1 456 U, 1064 U and 2280 U into knee joint. Each cartilage was sliced at a thickness of 4μm and 10 μm after formalin fixation, decarburization and preparation of paraffin block. 4 μm thickness sections were stained by Safranin-O stain and observed by optical microscopy. We confirmed thickness of cartilage, normal area, moderate degeneration area and severe degeneration area. In undyed 10 μm thickness sections by bioacoustic microscopy. Since each cartilage layer was divided into superficial, middle and deep layer, we calculated the speed of sound and the attenuation of each layer. The damage proceeds to deep layer from superficial layer.

4. Acoustic characteristics of cartilage

In the analysis of cartilage, we select three region for measure the acoustic characteristics, and compare them in each sample. The region A has less damage from the own weight of rabbit. The region B has moderate damage from the weight. The region C has serious damage from the weight. These categories were determined by optical microscopy observation of the orthopedic surgeon. In this investigation, we tried to examine relationship between the acoustic characteristics and damage of cartilage by differences in the degree of weight in the normal breeding. Figs 2 and 3 show analysis results from cartilage of the speed of sound and the attenuation.

The speed of sound in each layer in region A which has less damage are shown similar value as reference value [1]. The Speed of sound is slower in accordance with the progression of damage in superficial layer. On the other hand, the attenuation is higher with the progression of damage in superficial layer. It is assumed that these changes of acoustic characteristics occurs by the cartilage damage at surface area, destruction of the collagen network, decrease in proteoglycan and increase of water content.

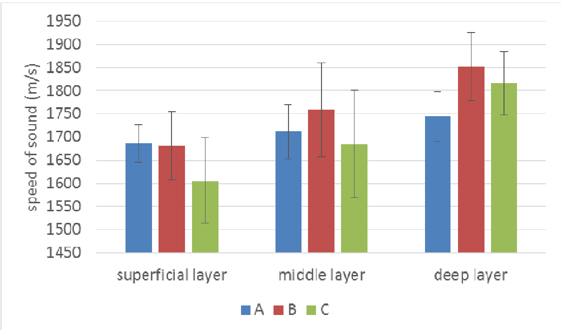

Fig. 2 Normal rabbit cartilage results of speed of sound

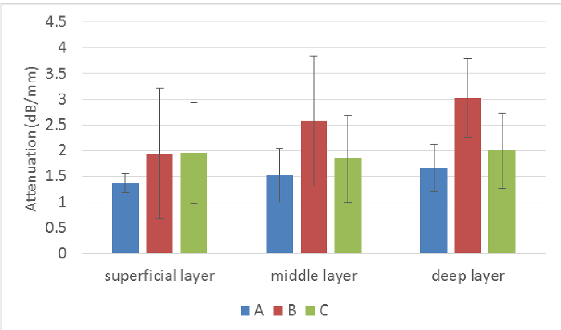

Fig. 3 Normal rabbit cartilage results of attenuation

5. Acoustic characteristics of meniscus

In the analysis of meniscuses, we created two sample of plane A and B to examine the anisotropy. Figs 4 and 5 show the analysis results of the speed of sound and the attenuation in meniscus. The difference of values on the speed of sound and the attenuation is observed between plane A and plane B. It is assumed that the anisotropy is high in meniscuses. On the other hand, the correlation of the acoustic characteristics and damage not confirmed.

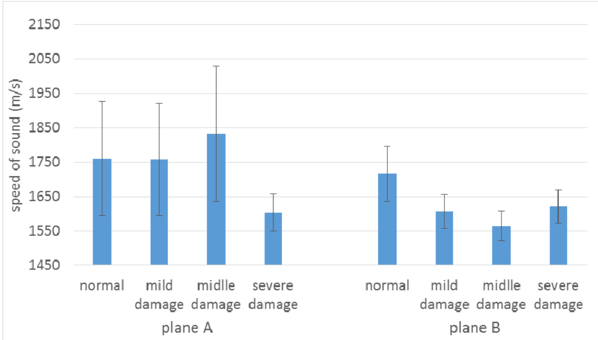

Fig. 4 Inner meniscal of speed of sound

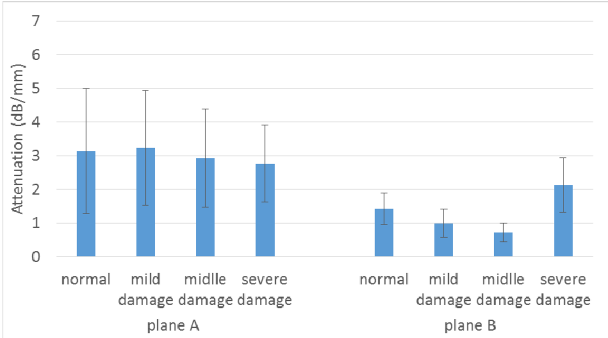

Fig. 5 Inner meniscal attenuation

6. Conclusion

We tried to measure and analyze the acoustic properties of the cartilage of rabbit by using a 80 MHz ultrasound. The bioacoustic microscopy could detect different features compared with a pathology, because the different tissue structures were seems in two dimensional measurement image of the speed of sound and the attenuation. The cartilages had the different tendency in superficial, middle and deep layer. In analysis of rabbit cartilage, we can observe changes of acoustic characteristics due to cartilage damage. However the accuracy of detection of difference of tissue property is not enough in present. The measurement of the cartilage and the meniscus with higher frequency is our next assignment.

References

1. Y. Saijo: IEEE Trans Ultrason Ferroelect Freq Contr (2007) pp1571-1577
2. Y. Saijo: IEEE International Ultrasonics Symposium (2009) pp37-40
3. Y. Hagiwara: J Orthop Res 27 (2009) pp236-242
4. Y. Hagiwara: Int Orthop, Vol. 6, No. 1 (2012) pp185-190