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Study for Imaging of Inside Bone using Ultrasonic Frequency Characteristics
超音波周波数特性を利用した骨内画像化の検討

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1. Introduction

Society is aging at an ever-increasing pace. Osteoporosis, bone tumors and other forms of bone morbidity increase with advancing age. Ultrasound is non-invasive, easy to use and inexpensive compared with X-ray (CT) or MRI. Therefore, the diagnosis using the ultrasonic image for inside the bone is eagerly desired. The purpose of this study is to diagnose the bone diseases using the ultrasonic image. In the previous study, we found the special phenomena that the intensity of the ultrasonic wave penetrated through a sample bone (spine of a pig) started to increase from 500kHz and became maximum at about 2MHz using three kinds of probes, and suggested a new imaging method utilizing the frequency-dependent characteristics of bone. In this paper, we report a newly developed wide-band probe for the imaging of inside bone and the results of the measurement for the frequency-dependent characteristics of a sample bone (spine) using it.

2. Experimental system and measurements

A schematic and overview of the experimental system are illustrated in Fig.1 and Fig.2. In the experiment, a new-type focused probe is used. The probe consists of two kinds of transducers; 5MHz transducer with 20mm diameter and 0.5MHz transducer with 30mm diameter. These two transducers are pasted together with bonding agent. The focal point of the probe is 40mm. The measurement system consists of a pulser/receiver (Panametric Model 5800), a function generator (NF WF1965), a power amplifier, a high sensitivity hydrophone with large diameter (9mm) and an oscilloscope (Techtronix TDS5104B). The hydrophone is located in the position of 10 mm far from the focal point of the probe. And a sample bone (spine) is inserted at the focal point of the transducer.

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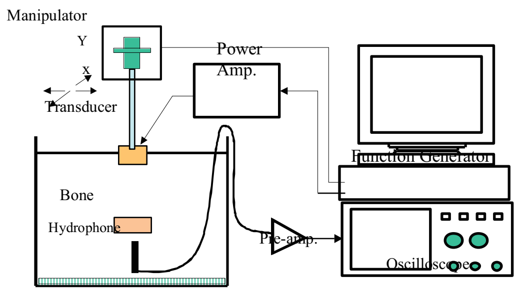


Fig. 1 Schematic of the experimental system

Fig.2 Overview of the experimental system

3mm (thickness) 11mm (thickness)

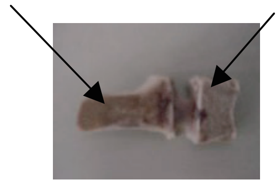


Fig.3
Sample Bones (spine)

As shown in Fig.3, two sample bones with 3mm and 11mm in the sliced thickness are used.

At first, we measured the frequency band width of the probe using the pulser/receiver and the hydrophone. The single pulse wave (approximately -200V) is transmitted from the probe, and received by the hydrophone directly. The received waveform and its frequency spectrum are displayed on the oscilloscope (Fig.4). Next, We measured the frequency-dependent characteristic of the sample bones using burst waves transmitted from the probe using the function generator. The burst waves transmitted from the probe are received by the hydrophone through the bone. The frequency of the burst waves is continuously changed from 0.3MHz to 10MHz.

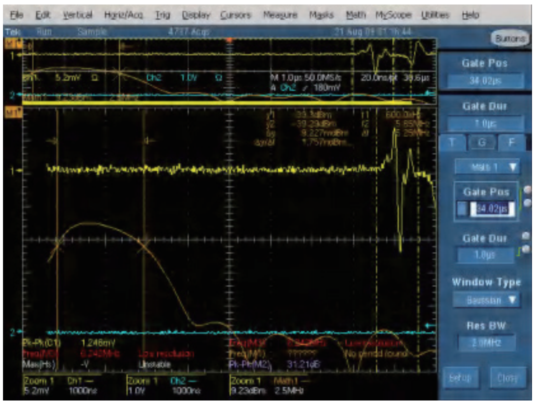
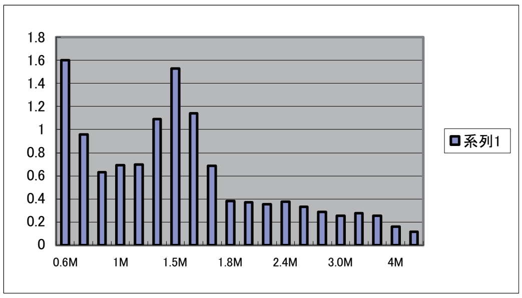
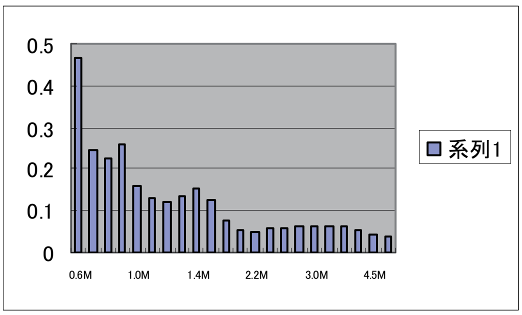


Fig.4 frequency spectrum of the transducer



(a) 3mm (thickness)



(b) 11mm (thickness)

Fig.5 Frequency-dependent characteristic of the sample bones

3. Results and discussions

As shown Fig.4, a wide-band frequency characteristic with 0.6MHz to 5.5 MHz was obtained. Therefore, in the measurement of the frequency-dependent characteristic, the burst waves could be transmitted without distortion between approximately 0.5MHz to 6MHz.

The frequency-dependent characteristics of the sample bones are shown in Fig.5. In Fig.5 (a), the intensity of the penetrated signal through the bone decrease from 0.6MHz to 0.8MHz. It shows a normal attenuation. However, the intensity increases from 0.8MHz and become maximum value at 1.5MHz. And after that, it decreases. The phenomenon is the same as in the previous experiment. And also it can be seen at 1.4MHz in Fig.5 (b), but the intensity is small. This is considered that the attenuation of the ultrasonic wave through the bone of 11mm thickness is large.

4. Conclusions

We developed a wide-band frequency probe and measured the frequency-dependent characteristics of the sample bones using it. In this study, the most effective thing is that the measurement of the wide frequency range became possible using (only) one probe, and the special phenomena depend on the frequency characteristics of the sample bones were found. It is suggested that the results are useful to obtain the image of inside bone.

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