2P5-3

Fundamental Study on Application of Ultrasonic Computed Tomography in Bone Existing Region

骨存在領域での超音波 CT の適用の基礎検討

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1. Introduction

Currently, echo imaging is widely used as a medical imaging method due to its portability, low cost and spatiotemporal resolution. In recent years, a method using USCT (Ultrasound computed tomography) has become practical as another method. USCT acquires reflected wave as well as transmitted wave, which can reconstruct the image of medium sound speed and attenuation profile.

Greenleaf *et al.*[1] showed that sound speed and attenuation index could be used to distinguish benign masses from cancer by measuring the sound property in a breast. However, this method was not used as populer clinical imaging method due to the limited performance of computer in those days.

With the development of computers in recent years, image reconstruction using USCT has become possible with practical accuracy and time. Duric *et al.*[2] developed the Computed Ultrasound Risk Evaluation (CURE) for the whole breast imaging system with high performance computing system. In this system, sound speed and attenuation profile in the breast is main target for diagnosis of breast cancer.

For the purpose of expanding the measurement object using USCT to areas other than the breast, we aim to apply USCT with shadow-less imaging possibility to the orthopedic field.

In this research, estimation of USCT for soft tissue in joint region is studied. Theoritical maximum lateral resolution is acquired when paths from each elements on a ring array transducer to scattering points is sured with no bone obstacles. However, in orthopedics region bones obstacle the paths. Then, lateral resolution depend on position relationship between points of interest and bones in the cross-sectional plane. In this paper, we examined the practical feasibility of ring array imaging in the presence of bone by examining the lateral resolution of each pixel.

2. Method

2.1 Lateral resolution and F number of ring array transducer

When the coverage of shadow in the propagation path to the point of interest is changed, the F number changed. The lateral resolution is determined by the F number. The F number is calculated from opening of transducer and distance between opening and a point of interest. When using ring array transducer, opening is distance between each edge of the arc when the arc length is less than half of circumference. When the arc length is larger than half of circumference, lateral resolution is not improved any better. In this simulation, the frequency is 3.5 MHz and transmission wave is 2 cycles pulse wave. In this preliminary research, diffraction and refraction effects are ignored.

2.2 Calculation of F number and lateral resolution

In this simulation, an axial cross-sectional x-ray CT image of the knee joint was used as an example of the image of bone exiting region. The CT image was acquired from IMAIOS, a service offering various medical images includes x-ray CT images. For considering a simple model, bone and other soft tissue was binarized. The schematic image of the next process is shown in the **Fig. 1.** At a target pixel, whether there was bone in a straight line between each element on the ring array and the target pixel was judged. In this step, elements which there was no bone on the line defined as effective elements. At one pixel, when the blocks of consecutively adjacent effective elements in the ring array transducer are regarded as one block and the largest one of the blocks was regarded as an array transducer, its F value was determined as the F value at that pixel. This procedure was applied at all pixels. After that, from the relationships between F number and lateral resolution which acquired in 2.1 results, lateral resolution distribution was obtained.

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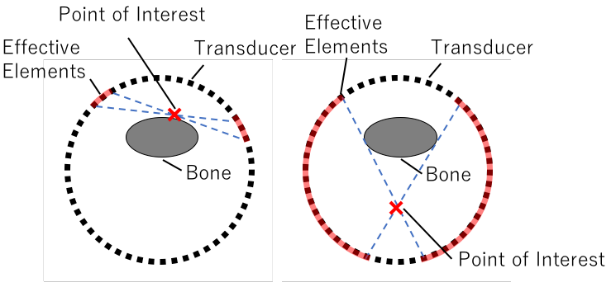


Fig. 1 Schematic image of point of interest, F number and effective elements.

3. Results and Discussions

The results of 2.1 is shown in the **Fig. 2**. When the arc of array transducer as an effective aperture was larger than a half of circumference, lateral resolution was 200 μm. As the F value increases, the resolution decreases. Thus, maximum resolution is about 200 μm, when there is no shadow of the bone.

The results of 2.2 is shown in the **Fig. 3**. With the frequency used for this study, the resolution around the bone and distant was about 2.0 mm ~ 5.0 mm and 200 ~ 400 μm. In the furure, we will implement an experimental study using a ring array transducer which has 20 cm diameter and 2 MHz frequency, and multiplexer, the Verasonics system (Verasonics, Inc. WA, USA) to examine the simulation study.

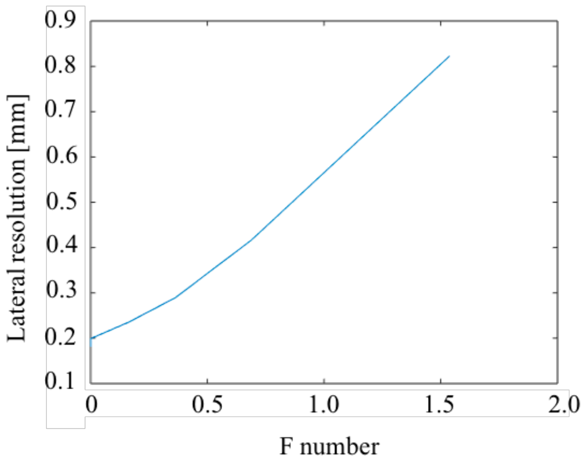
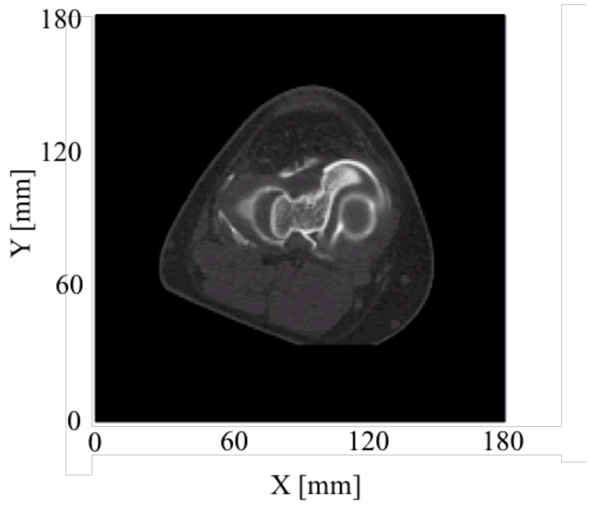


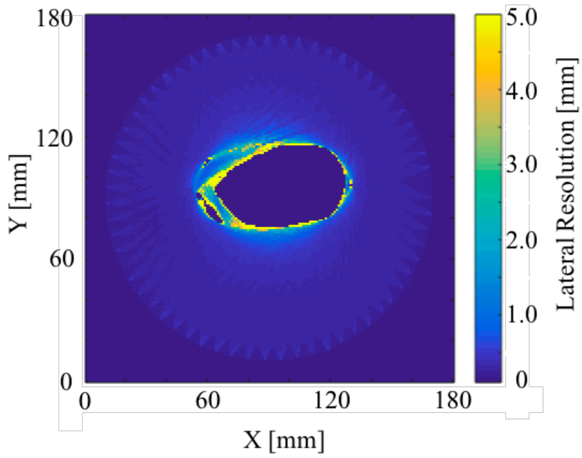
Fig. 2 F number vs lateral resolution

4. Summary

USCT application for orthopedics region was investigated. For scatterer imaging, F number distribution and lateral resolution map was presented. In this sample, pixels around the bone had about 2 ~ 5 mm lateral resolution, and distant region pixels had 200 ~ 400 μm lateral resolution. For future work,



(a) X-ray CT image of knee joint



(b) Lateral resolution map

Fig. 3 Lateral resolution map of knee joint

We will consider various subjects of orthopedics area and comprehensively. Also, increase the frequency and consider how far this system can increase the resolution in the vicinity of the bone.

References

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2. N. Duric et al., Medical Physics. **34,** 773-85, (2007).