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Ultrasonic Circular Probe with Through Hole for Medical Applications
医療応用のための貫通孔を有する超音波円形プローブ

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1. Introduction

Ultrasonography is widely used for diagnosing cancer, cardiac motion, blood flow, a fetus body and others, because an examination can be done without the need for dessection. Generally, ultrasonography is used for preoperative examinations and most ultrasonic probes are not designed to support in surgical operations. We are developing ultrasonic probes to examine lesion area directly during the surgical operation. In this paper, we propose the use of an ultrasonic circular probe with a through hole to support operation.

2. Ultrasonic circular probe

Fig. 1 shows a photograph of a circular ultrasonic probe, and **Fig. 2** shows a schematic illustration of it. To do a surgical procedure such as a biopsy, a needle is inserted into the through hole. We used an ultrasonic transducer made of PZT-epoxy 1-3 composite. The driving frequency is 15 MHz, and the outside and the inside diameter is 3.5 mm and 1.0 mm respectively. A spike-like voltage of 270 V was applied to transmit the ultrasonic pulses.

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Fig.1 Photograph of ultrasonic circular probe.

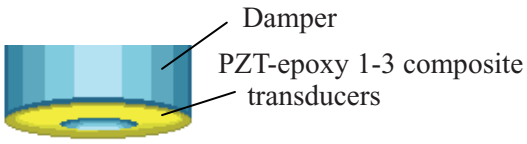

Fig.2 Circular type ultrasonic transducer.

3. Measurement method

To use the probe to support operations, we need to detect both a lesion area and the position of the needle tip through the hole at the same time. We proposed a detection of lesion area by pulse echo method and needle tip by TOFD (Time of Flight Diffraction) method. **Fig. 3** illustrates the combination of pulse echo method and TOFD method. As shown in **Fig. 4**, the TOFD is a method

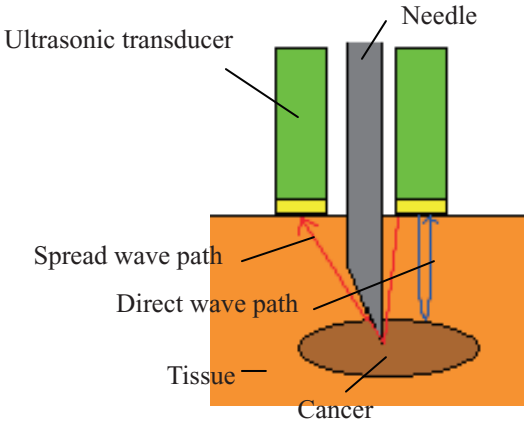

Fig.3 Combination of measurement combined TOFD method and pulse echo method.

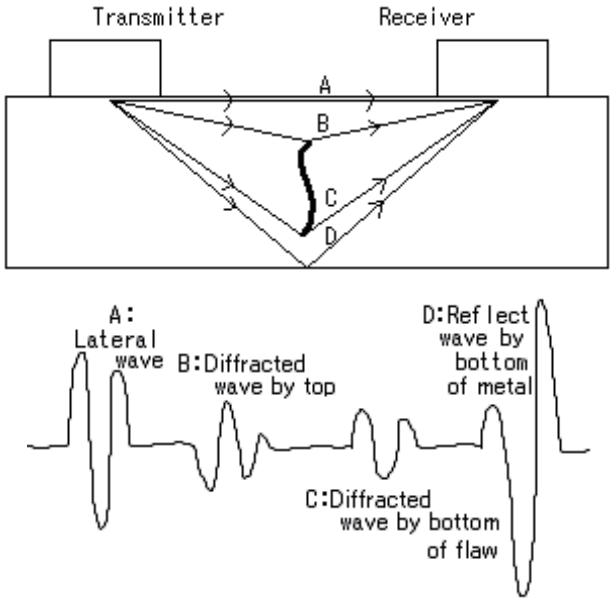

Fig.4 Principle of TOFD method [1].

that enables flaws in metal to be observed**.** A transmitter emits an ultrasonic wave at an angle to a flaw. The emitted ultrasonic wave is diffracted by the top and bottom of the flaw and reaches the receiver. The receiver detects a lateral wave shown by A, a diffracted wave by the top of the flaw (point B), a diffracted wave by bottom of flaw (point C), and a reflected wave by bottom surface of the metal (point D). The position and size of the flaw are estimated by the arrival time lags of the wave pulses. We used the TOFD method to detect the position of the needle.

4. Experiments and Discussion

We first examined pulses received from the pulse echo and the TOFD method for an agar. The circular probe was attached onto the agar as shown in **Fig. 5.** Agar with a height of 11mm was put in a plastic vessel. The needle with a diameter of 0.6mm was fixed to a z-axis stage and inserted into the agar through the hole of the probe. We moved the needle under the depth of 5 to 11mm until the needle contacted to the bottom of the vessel, and observed the diffracted wave from the needle tip.

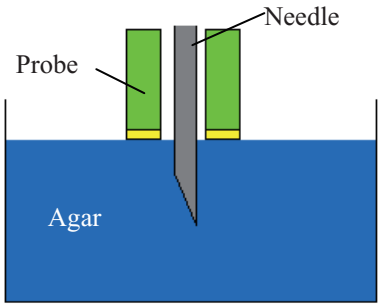

Fig.5 Experimental setup.

Fig.6 shows a waveform obtained at a depth of 7mm. Both diffracted wave from needle tip measured with the TOFD method and reflected waves from bottom of the vessel measured with the pulse echo method were observed. As shown in **Fig. 7**, the receiving time diffracted from the needle tip increased with the distance of the ultrasonic transducer to the needle tip. An experiment using a chicken fillet instead of the agar was also done, and the result is shown in **Fig. 8**. A similar waveform to that in the agar was observed.

5. Conclusion

We confirmed the positions of both a needle tip and a bottom surface of the agar which corresponds to a lesion area by combining the TOFD method and pulse echo method using the ultrasonic circular probe with a through hole.

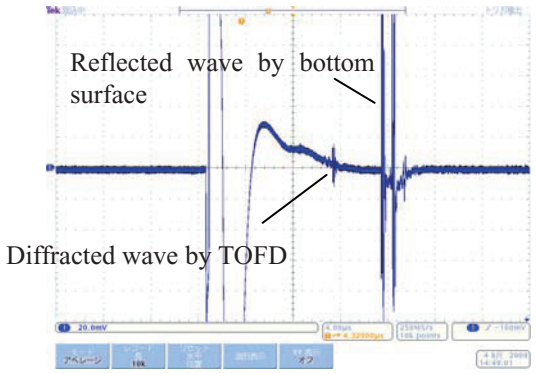

Fig.6 Waveform of TOFD and pulse echo.

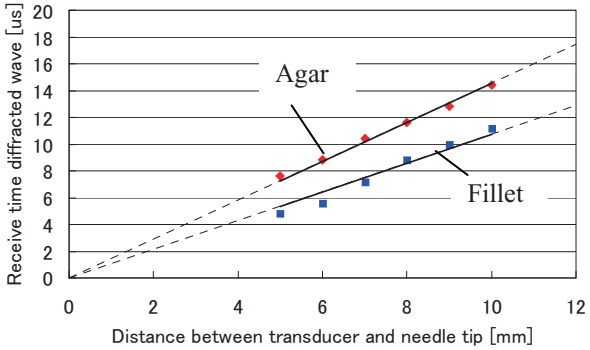

Fig. 7 Receiving time of diffraction wave by needle tip.

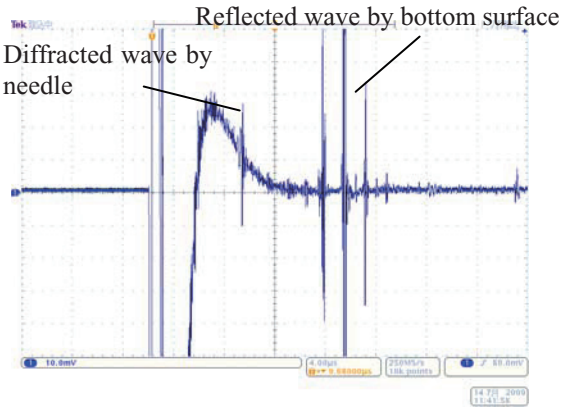

Fig.8 Waveform of needle in fillet.

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References

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