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Closely-contact body surface scanning mechanism for the acoustic tomographic measurement of the visceral fat area

音波トモグラフィ内臓脂肪検査のための体表密着走査機構の検討

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1. Introduction

The ultrasound tomography has been studied for the reconstruction of the abdominal sound speed image aiming to measure the visceral fat area.[1,2] The method is based on the travel time observations of the sound waves transmitted through the abdominal medium. To realize the method as a clinically available equipment, an automated scanning machinery has to be installed keeping close contact between a transducer and a human abdominal body surface. To this end, to-and-fro movement scanning equipment including the attachment of the elastic coupling gel hemi-sphere in front of the transducer surface was developed. Using the equipment, acoustic coupling property between the transducer and the target object was examined. As a result, the desired pushing status was detected from the observation of the received sound wave signals while preserving sufficient contact without harm to the body.

2. Problem setting

2.1 Body surface contact scanning structure

A tomographic sound wave observation system around the abdominal body surface, we used in this paper, is as shown in Fig.1. Facing pair of piezoelectric transmitter and receiver (circular aperture diameter 40 mm) are mounted on the rotation circular ring (diameter 470 mm) and rotated around the body surface. In addition, transducers can be moved along the guide rail pipe in to-and-fro direction against the body surface. By pushing the transducers at each observation points around the body surface, sound waves transmitted through the body can be observed. Urethane gel hemi-spheres (diameter 80 mm) were attached in front of the transducers. It is noted that the hemi-sphere gel coupler plays a role to maintain the good contact between the transducer and the body surface regardless the change of the contact condition.

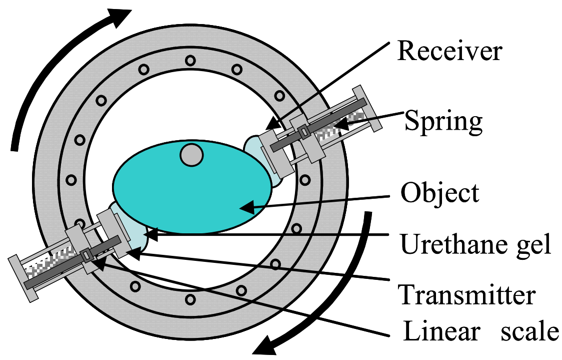

Fig.1 Body surface scanning machinery used in the experiment.

2.2 Observation of the transmitted wave

A abdominal phantom specimen was prepared as a test object. Using the present equipments, a facing pair of transmitter and receiver is made advanced between the intervening object medium. The distance was measured with a linear scale meter attached to the transducer equipment. Assigning an object surface position as origin, they were approached gradually at the positions: (a) 0 mm, (b)5 mm, (c)10 mm, (d)15 mm. The observed waves are shown at each positions in Fig.2. We can see that magnitude of the signals are changed before and after the contact. It is therefore expected that the received sound waves can be used for the monitoring of the contact status. Note that the property may be dependent on the degree of parallization between the body and transducer surface as shown in Fig.3. To elucidate the points, the examinations will be made below including, (i) estimation of the contact state from the received wave information, and determination of the sufficient pushing distance of the transducer, (ii) precision and validity examinations of the travel time measurement (i.e., sound speed measurement)

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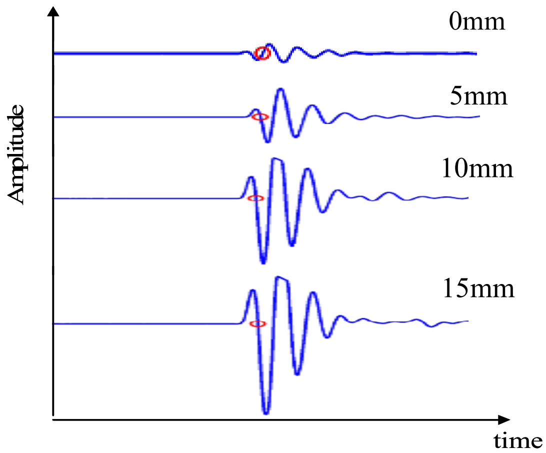

Fig.2 Variation of the observation waves with respect to the pushing distance.

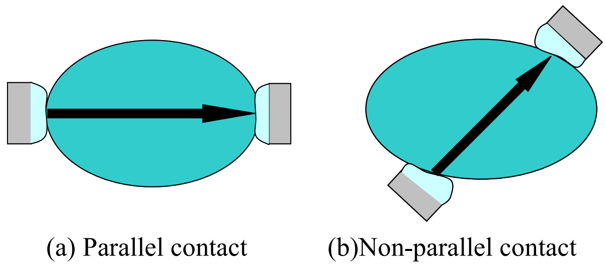

Fig.3 Change of contact condition between the body and transducer surface.

under the varying contact conditions (e.g., parallelism between body and transducer surface.).

3. Results and discussion

Experiment results of peak to peak amplitudes of the received waves with respect to the pushing distance of the transducers are shown in Fig. 4. Where (a) shows the results along the path in Fig.3 (a) (parallel contact), and (b) shows the results along the path in Fig.3 (b) (non-parallel contact). We can see that contact is sufficient at the distance greater than 15 mm for both of the cases, since the amplitudes are saturated in the regions. Next, the travel times were measured from the zero crossing point of the first arrival wave at each distance. The measured results are shown in Fig.5 with the marks. For comparison, theoretical curves are shown with the lines, where sound velocity of the medium 1495 m/s was used for the theoretical calculations. The measured travel times are in good agreement with the theoretical ones over the whole region regardless of the change of the contact conditions. The results demonstrate that travel times can be precisely measured even at the weakly pushed contact region. This is a favorable result, since the pushing force should be weak enough not to give pain to the patient.

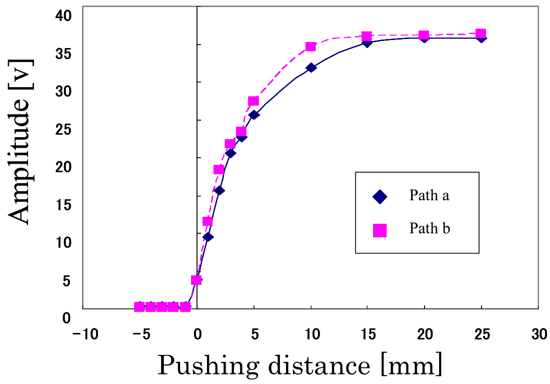

Fig.4 Relationship between the received wave amplitude and the pushing distance against the body surface.

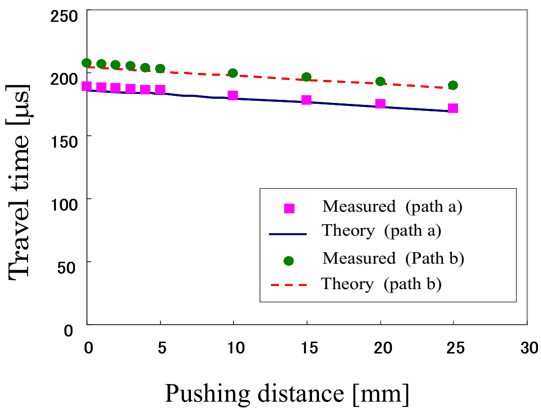

Fig.5 Relationship between the travel time and the pushing distance against the body surface.

References

1. K.Nogami, A.Yamada, “Evaluation experiment of ultrasound CT for the abdominal sound speed imaging”, Jpn.J.Appl.Phys., 46, 7B,4820-4826 (2007).
2. K.Kawamoto, A. Yamada, and M.Wada: “Accuracy Verification of Visceral Fat Area Measurement Using Ultrasound Tomography”, 30th. Symp. Ultrason. Elec., 1P2-17(Nov. 2009).