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Effect of PRF on Microcalcification Detection in Color Flow Imaging (Part 2)

CF モードにおける微細石灰化検出に対する PRF の影響 (第２報)

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1. Introduction

When strongly reflecting objects such as calcifications in soft tissue is scanned in Doppler mode, fluctuation of red and blue mixture behind the reflecting object appears. This phenomenon has been called "twinkling sign/artifact" [1]. Although the twinkling sign had a potential in clinical diagnosis [1-4], the occurrence mechanism of this phenomenon has not been clarified yet. Liu et al. experimentally confirmed the relationship between the twinklig sign and the ultrasound radiation force induced micro oscillation of the micro particles [4]. In the previous research, the relationship between pulse repetition frequency (PRF) and echo signals was investigated using a single transducer [5,6].

In this study, *in vitro* experiment was performed to investigate the effect of PRF of ultrasound on the echo of the micro glass bead using a medical ultrasound machine and a linear array probe.

2. Method

In this study, the medical ultrasound machine (GE Healthcare Japan, LOGIQ S8 pilot unit) and the linear phased array probe (GE Healthcare Japan, ML6-15-D) were used for the ultrasound scanning of a soft tissue-mimicking phantom in color flow (CF) mode, as shown in **Fig. 1**. The ultrasound scanning conditions are summarized in **Table I.**

The tissue-mimicking phantom had two gelatin gel layers to sandwich a glass bead. Concentration of the gelatin gel is set to 10%. In the phantom, two glass beads whose diameters are 536 μm and 1189 μm were placed on the surface of the first layer separately. With each PRF, successive echo signals obtained by the medical ultrasound machine were transformed into I/Q signals and stored in the machine. In addition, the finally displayed images were stored as movie of 100 frames. A region of interest (ROI) including the glass bead, and the size of the ROI was set as 5 x 5mm^2 (244 x 245 pixels). We measured the total number of the color pixels in the ROI and calculated its temporal average.

Table. I Ultrasound scanning conditions

Scan mode	Color flow (CF)
Center frequency [MHz]	5
Image depth [cm]	2.5
Focus position [cm]	2.6
Packet size	8
Acoustic output [%]	100
PRF [Hz]	300-3900

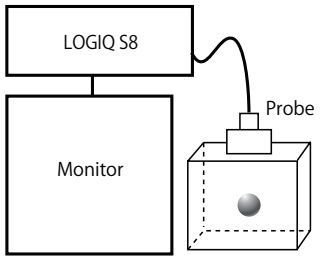

Fig.1 Block diagram of experiment.

Variance of echo signal σ^2 was calculated as follows:

$$\sigma^2 = \frac{1}{N}\sum_{i=1}^{N}\{\tilde{r} - r_i\}^2, \quad (1)$$

$$r_i = I_i + jQ_i, \quad (2)$$

where, $\tilde{r}$ is the average signal of r_i, N is packet size and was set as 8 in this study, I_i is i^{th} in-phase component and Q_i is i^{th} quadrature-phase component. These calculations were processed using software developed in Matlab (Mathworks, Natick, MA).

3. Results

As an example, an echo signal from the glass bead of diameter 1189 μm with 300 Hz of PRF, is shown in **Fig. 2**. It was clear that long duration echo follows after first peak. **Figure 3** describes

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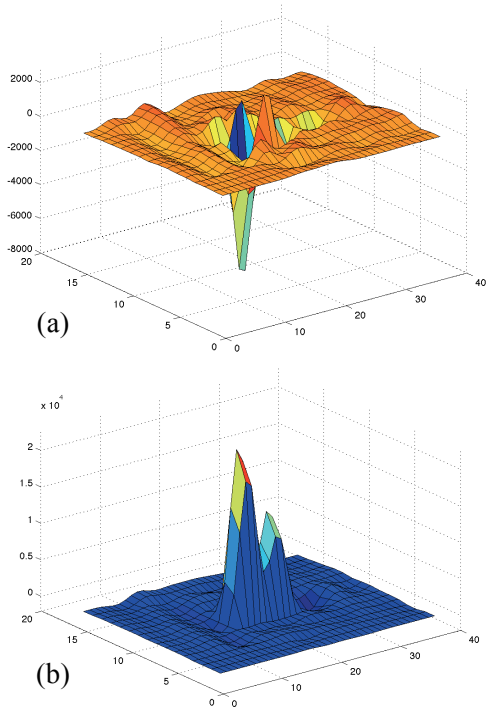

Fig.2 (a) I and (b) Q signals of echo from a glass bead (1189 μm diameter).

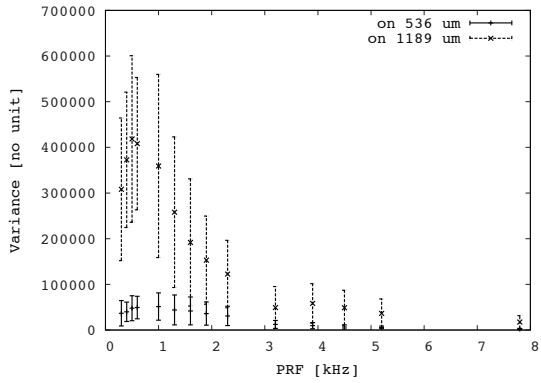

Fig.3 Variances of echo signals with various PRFs.

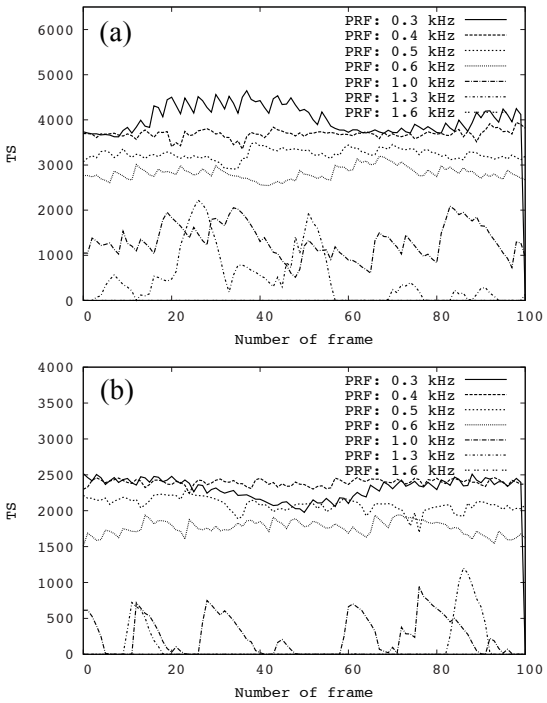

Fig.4 Number of pixels with various PRFs. Diameter is (a) 1189 μm, (b) 536 μm.

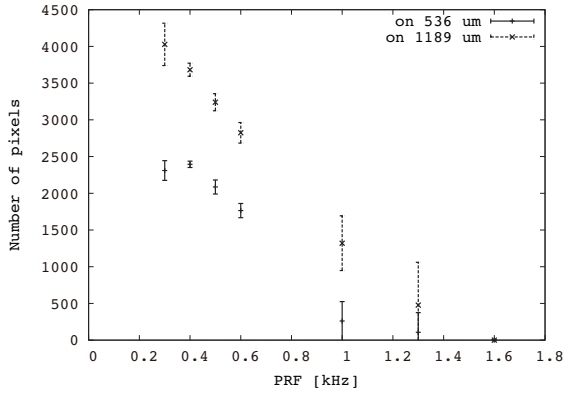

Fig.5 Averages of number of pixels with various PRFs.

variances of the echo signals with various PRFs. **Figures 4 and 5** show the number of pixels of the twinkling sign with various PRFs. The variance decreased in higher PRF and this denoted the same tendency of the displayed twinkling sign.

3. Conclusion

In this study, we examined the effect of PRF on the echo signal from the micro glass bead using the medical ultrasound machine and the linear array probe. The result showed that the lower PRF makes much variance of the echo signals. As a future work, further investigation on machine parameters such as wall filter will be conducted.

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