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Improvement of Elastogram by Insertion of Damper Layer
緩衝層挿入による elastogram の改善

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1. Introduction

In resent years, some techniques of the absolute elasticity distribution measurement have been reported in elastography which is an ultrasonic technique that images the distribution of the elasticity inside biological tissue.
Using the Trasmit/Receive face of a transducer as a compression board is regarded as a practical means in elastography because of its convenience. It is necessary to be careful with the specific distribution of strain produced by the shape of the Trasmit/Receive face [1]. In general, this stress applied at the surface of a tissue is transferred radially to the vicinity, even inside a multi-layered tissue. In this case, the nonuniformity of the strain is clearly observed at the tissue surface, especially at the edge of the the compression board, and is transferred to the deeper layers. This nonuniform strain causes inappropriate estimation or imaging of elastic moduli. In this study, the insertion of a damper between the transducer and the tissue is proposed as a technique for softening nonuniformity. An optimization tool for applying strain was developed. Finally, using the tool, the effectiveness of inserting a damper was performed.

2. Design of Simulation Tool

The simulation tool developed in this study consists of 2-dimentional structural analyses based on the finite element method and 2-dimentional sonic analyses based on the finite difference time domain (FDTD) method. The tool is used to calculate the deformation of compressed tissue from a given (assumed) model of elasticity distribution and perform sonic analyses to obtain pre- and post-compression echoes. A strain image is obtained from these echoes via a cross-correlation process between them. Using this tool, the strain distributions with and without the damper are estimated, and the uniformities of the strain are assessed.
An assessment model is illustrated in Figure 1. The tissue consisted of three layers of 50 kPa 100 kPa and 50kPa in Young's modulus, and the damper was 50 kPa and 0.4 mm in thickness. The transducer was 60% of the width of the tissue model. Flatness, which is a ratio of the strain directly under the edge of the transducer to the strain directly under the center of the transducer in the same depth, is referred to as an assessment index.

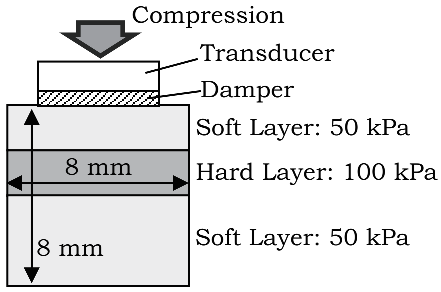

Figure 1: Assessment model.

3. Effects of Insertion of Damper in Structural Analysis

Figures 2 (a) and (b) show the results of the strain distributions of the structural analysis without and with the damper, respectively. An edge effect is can be seen in each case however, only Figure 2 (b) clearly shows the nonuniformity in the middle layer. The results shown in Figure 3 demonstrate the flatness in the depth direction. The flatness at the tissue surface is markedly improved.

4. Effects in Sonic Analysis

These results obtained in the structural analysis are reflected in the

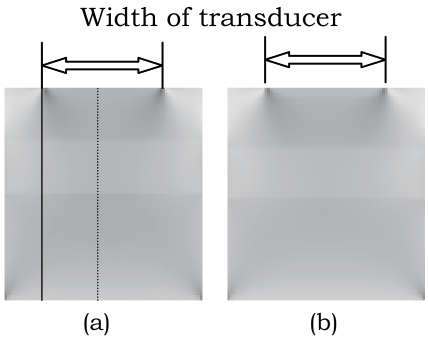

Fig. 2 Calculated strain distributions. (a) without damper, (b) with damper.

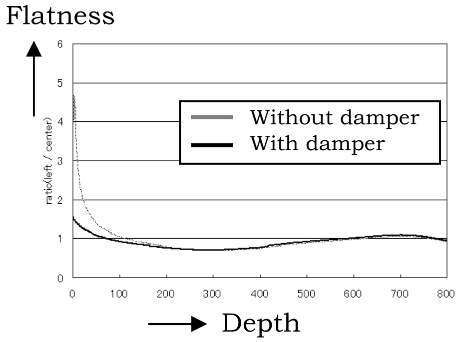

Fig. 3 Flatness in depth direction.

simulation tool, then, the sonic analyses with a 10MHz transducer consisted of 240 point sound sources are executed in the tool. Figures 4 (a) and (b) demonstrate the results of the strain distribution obtained from the sonic analyses. A reasonable strain distribution is can be seen in Figure 4 (a) with the damper. The improvement of the flatness shown in Figure 5 was from 21 to 3.5 at the tissue surface and from 13 to 1.9 of the average inside the hard layer of a 100 kPa.

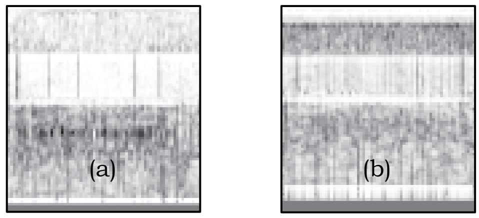

Fig. 4 Results of strain distribution obtained from FDTD analyses. (a) without damper, (b) with

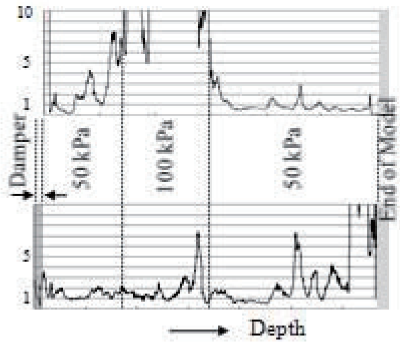

Fig. 5 Results of strain distribution obtained from sonic analyses. (a) without damper, (b) with

5. Conclusions

Possible improvement in elastography by the insertion of damper was presented. Future work will be the automatic optimization of the damper design.

Reference

[1] E. Konofagou, P. Dutta, J. Ophir, et al: Reduction of stress nonuniformities by apodization of compressor displacement in elastography. Ultrasound in Med & Biol., No.9, 1229-1336, 1996.