Comparing Portable and Clinical Ultrasound Systems Using 3D Printed Breast Phantom Inserts

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Background

- Late-stage breast cancer rates in the Pacific where mammography services are limited are exceedingly high. Therefore, alternative accessible breast cancer screening technologies such as portable ultrasound is needed.
- Little is known about the performance of portable ultrasound when compared to clinical ultrasound for use in breast cancer screening.
- By utilizing 3D printing technology, we designed breast phantom inserts to replicate various types of lesions [1].
- In this study, we utilized 3D printed breast phantom inserts to compare portable and clinical ultrasound lesion detection performance.

Methods

- Four different breast inserts were designed using FreeCAD (version 0.19) to replicate different lesion detection properties. The first insert compares lesion shape, the second insert investigates depth and size, the third insert looks at fiber diameter, and the fourth insert looks at clusters.
- The breast inserts were placed in a gelatin-based breast phantom created for ultrasound [2] and a vacuum chamber was used to extract air bubbles. See Figure 1 and 2.
- Using clinical ultrasound (Philips EPIQ 5G), and portable ultrasound (GE Vscan Extend) various images were captured of identical angle and orientation for both devices. See Figure 4-7.
- The number of lesions visualized were counted and presented as a percentage of lesions detected.

Figure 1. Using a vacuum chamber to extract air bubbles during the breast phantom creation process. Air bubbles could create unwanted artifacts if present during phantom creation.

Methods (continued)

Figure 2. Gelatin breast phantom using graphite powder. The surface bubbles are a result of the vacuum chamber.

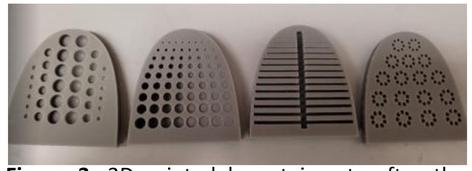

Figure 3. 3D printed breast inserts after the curing process. Printed using a photopolymer resign (Formlabs Inc Rigid resign).

Results

Clinical Ultrasound (Philips EPIQ 5G) **Portable Ultrasound (GE Vscan Extend)**

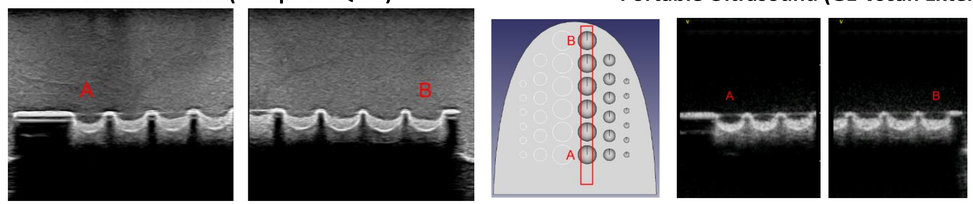

Figure 4. Example of breast insert 1 with clinical US on the left, and portable US on the right.

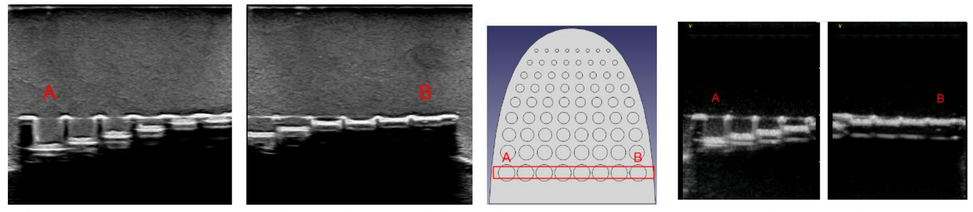

Figure 5. Example of breast insert 2 with clinical US on the left, and portable US on the right.

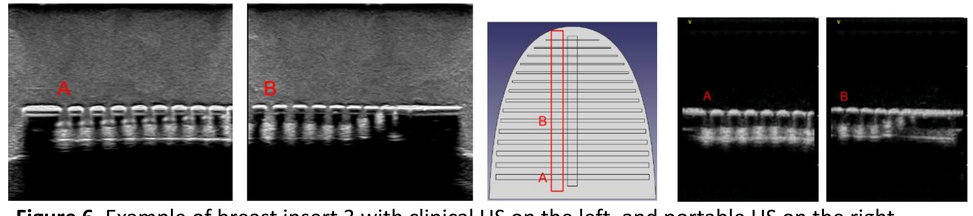

Figure 6. Example of breast insert 3 with clinical US on the left, and portable US on the right.

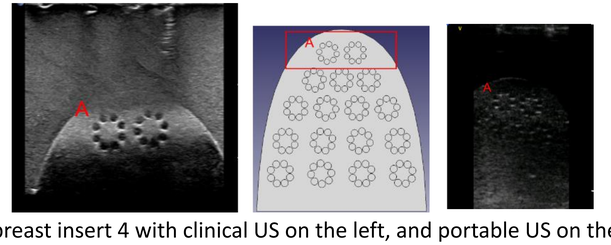

Figure 7. Example of breast insert 4 with clinical US on the left, and portable US on the right.

Results (continued)

Table 1. Lesion Detection Performance for Portable US and Clinical US

	Clinical US	Portable US
Breast Insert 1	18/18 (100%)	18/18 (100.0%)
Breast Insert 2	67/72 (93.1%)	65/72 (90.3%)
Breast Insert 3	24/30 (80.0%)	21/30 (70.0%)
Breast Insert 4	103/104 (99.0%)	58/104 (55.8%)

The portable ultrasound had a 100% lesion detection rate for breast insert 1, 90.3% for breast insert 2, 70% for breast insert 3 and 55.8% for breast insert 4 (Table 1). Clinical ultrasound had 100% lesion detection rate for breast insert 1, 93.1% for breast insert 2, 76.6% for breast insert 3, and 99% for breast insert 4.

Conclusion

- Portable ultrasound shows comparable lesion detection capabilities to clinical ultrasound in 3 out of 4 breast phantom insert tests.
- Portable ultrasound may have potential as a capable accessible breast cancer screening device in areas without mammography.

Future Work

- A reader study where different types of readers (radiologist, MDs, and general healthcare workers) are asked to assign a BIRADS score to breast ultrasound images with and without the aid of an AI system is currently in progress.

References

1. He, Y., et al., *3D-printed breast phantom for multi-purpose and multi-modality imaging.* Quantitative Imaging in Medicine and Surgery, 2019. **9**(1): p. 63-74.
2. Nguyen, M.M., et al., *Development of oil-in-gelatin phantoms for viscoelasticity measurement in ultrasound shear wave elastography.* Ultrasound Med Biol, 2014. **40**(1): p. 168-76.

San Antonio Breast Cancer Symposium- December 7-10, 2021