Skin conformity and reusability of molded silicone boluses for breast cancer patients with expanders

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PURPOSE

This study investigates the feasibility of making a standardized set of silicone boluses that could be reused on breast patients with expanders precluding the need for manufacturing a custom silicone bolus for each patient. We also compared the conformity between the custom silicone and Superflab boluses.

INTRODUCTION

Conforming traditional Superflab to a breast with expanders yields poor results, is time consuming and uncomfortable for the patient. Variations in the volume of air gaps for treatment can result in inconsistent dosage levels between planned and delivered treatment [1]. An alternative option is brass mesh; however, this method could increase the effective dose to the skin due to photoneutron production at high energies.[2] Silicone is tissue equivalent, comfortable and can be constructed to achieve a high degree of conformity. However, the process of designing a custom bolus, 3D printing molds, pouring and hardening silicone for each patient is time consuming. This study focuses on the feasibility of designing a standardized set of silicone boluses that can be reused on breast patients and provide better conformity than Superflab and other methods, precluding the need for manufacturing a custom bolus per patient.

MATERIALS AND METHODS

Bolus preparation:

- Boluses of 5mm thickness and varying dimensions were made in Raystation 10A on breast patients with expanders. The Adaptiiv (Halifax, Canada) software was used to create the two-part 3D mold shells for the silicone bolus. A fused-deposition modeling (FDM) 3D printer was used to print the molds. A two-part liquid silicone mixture (Smooth-On Ecoflex 00-30) was degassed in a vacuum chamber at 26 inHg for five minutes. This mixture was then poured into the shell and was allowed to harden overnight. The result is a soft, durable, tissue-equivalent bolus.

Air gap study:

- CT scans were acquired of different combinations of the silicone bolus and Superflab on the breast phantoms. 3D-printed breast phantom shells were scanned on top of a thorax phantom to mimic the external of a body and thus produce realistic air gap scenarios. For each breast phantom, five scans were acquired with its matching silicone bolus, three scans with a silicone bolus that seemed the next best fit, and one scan with Superflab. The volume of air gaps in the different scans were measured and compared using the RayStation threshold tool.

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RESULTS

Table 1 shows the average air gap volume for the different phantom-bolus and phantom-Superflab setups. The data called 'matching silicone bolus' represents the setups with the phantom and the silicone bolus custom-made for that phantom. The 'random silicone bolus' data represents the setups where the silicone bolus made for a phantom was removed and the therapists were asked to choose a different silicone bolus that best fit the phantom from the remaining options in order to gauge the reusability of silicone boluses.

	Measurement of air gap volume (cm^3)		
	Matching silicone bolus	Random silicone bolus	Superflab
Phantom 1	6.2	14.9	227.1
Phantom 2	7.5	39.1	98.4
Phantom 3	8.9	19.8	117.3
Phantom 4	27.9	30.2	162.4
Phantom 5	6.3	35.6	77.1

Table 1: average volume of air gaps per phantom setup

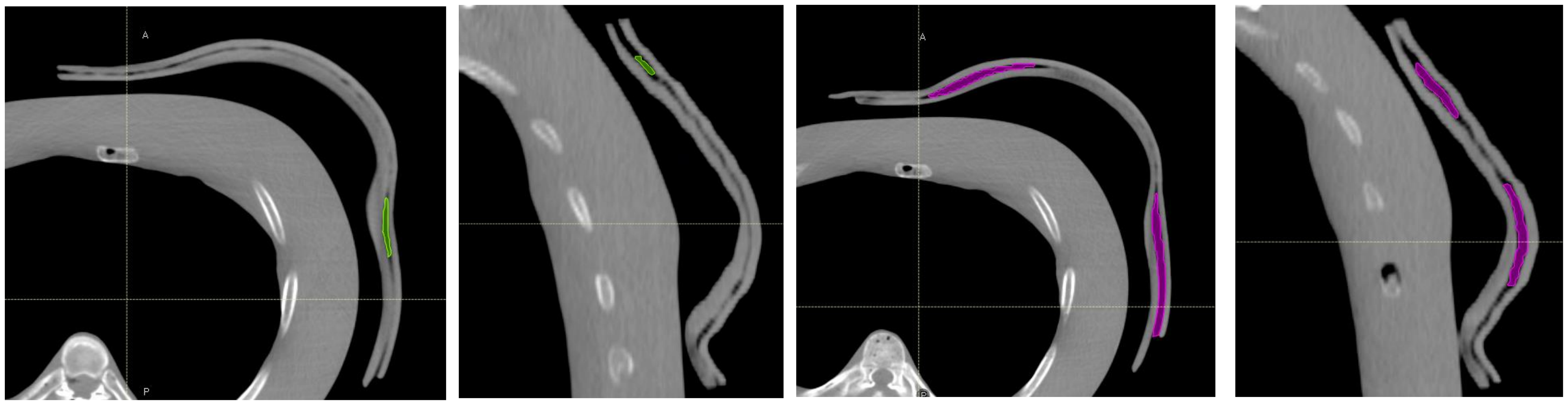

Figure 1: axial and sagittal CT scans of phantom 1 with silicone (green, on left) and Superflab (purple, on right)

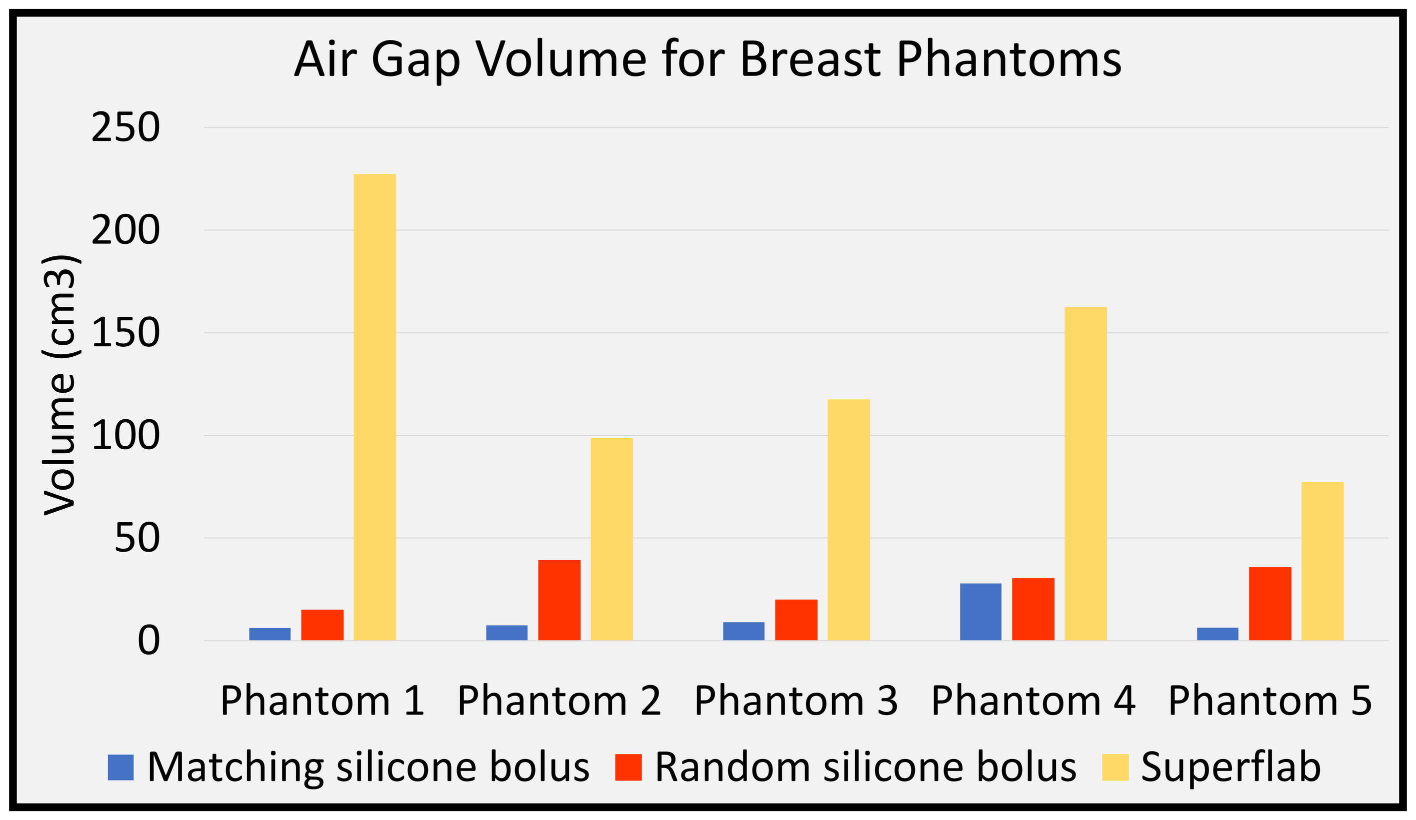

Chart 1: average volume of air gaps per phantom setup

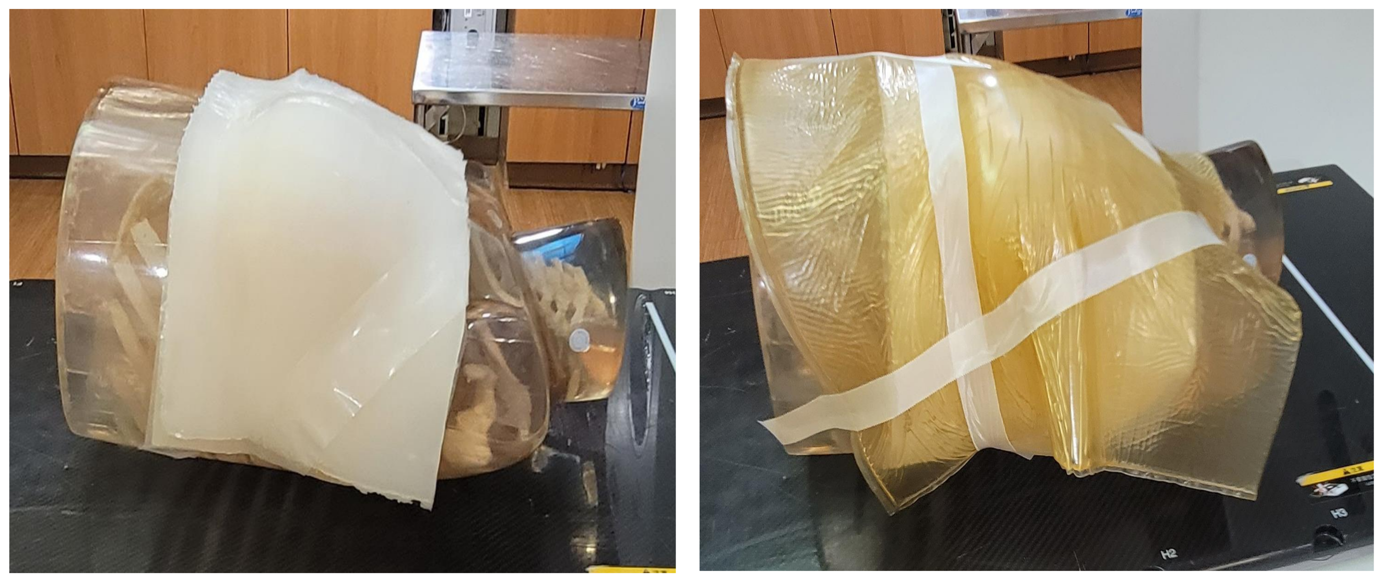

Figure 2: lateral view of silicone setup (on left) and Superflab (on right)

DISCUSSION

Silicone presented an undeniably superior conformity as evidenced by the 16-fold reduction in air gap volume in the matching silicone bolus data and a 6-fold reduction in the random silicone bolus data, both compared to Superflab. It is acknowledged that the sample size in this study is small. However, the preliminary data provides the support needed to persuade further studies on the benefit of using customized silicone bolus instead of Superflab for breast patients with expanders. Furthermore, the considerable decrease in air gap volume between the Superflab and random silicone setups show that it is advantageous to explore the possibility of creating a standardized set of silicone boluses for clinical use in future breast treatments instead of making a custom bolus for each patient.

CONCLUSION

In conclusion, using customized silicone bolus on breast patients provides superior conformity than using Superflab. The lack of need for special conditions in terms of cleaning and the ability to autoclave silicone multiple times without damage to it makes it an ideal material for repeated use in the clinic. An added benefit noted during the experiment was reproducibility. When using Superflab on breasts, it can be a challenge to reproduce the position of the bolus on a daily basis. However, the unique shape of the silicone bolus made it easier to reproduce the placement and decrease the presence of air gaps to a miniscule volume. Further trials and data need to be acquired to support the goal of this study and deduce the most used sizes and volumes of silicone boluses which could lead to a set of standard sizes.

REFERENCES

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