Weight Measurement and Volumetric Displacement of Breast Implants and Tissue Expanders
Why Port and Shell Volumes Matter in Breast Reconstruction, Augmentation, and Revision

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KEYWORDS
- Saline breast implants
- Silicone gel breast implants
- Breast tissue expanders
- Volumetric displacement of implants
- Weight measurements of breast implants
- Saline density
- Silicone gel density

KEY POINTS
- There are significant differences in weight and volumetric characteristics between silicone and saline breast implant of which most plastic surgeons are unaware.
- Plastic surgeons need to be aware of these differences for both in-breast implant exchange from saline to silicone conversions and 2-stage breast reconstruction.
- Until now, measuring the volume created by the expander has been solely reliant on using the volume of injected saline into the expander.
- The volume occupied by the tissue expander shell and filling port have been largely estimated or disregarded.
- In addition, these differences are commonly ignored in saline to silicone gel implant exchanges.

INTRODUCTION AND BACKGROUND

The aesthetic results and outcomes following breast augmentation and reconstruction with implants and tissue expanders continue to improve and are becoming increasingly accurate. With the advent of 3-dimensional imaging and simulation, very specific volumes of the breast may be calculated, simulated, and compared. Many plastic surgeons continue to be unaware of the differences between saline and silicone devices, and fail to consider the additional weight and displaced volume that the saline shell and expander components add to the weight and volume of the overall device. In addition, saline is more dense than silicone and adds slightly to the volume differences. These differences in volume are becoming more

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important in achieving optimal outcomes and symmetry. Finally, saline implants are filled in situ, so their weight and displaced volume does not include the implant shell. Silicone implants, however, are constructed, weighed, and volumetrically measured, including the shell weight and total displaced volume, by the manufacturer.

So what weighs more, saline or silicone? Silicone implants will float when placed in a saline bath because silicone is less dense than saline (Fig. 1). Saline implants hover just beneath the surface, because they are isodense with the saline bath (Fig. 2).

The relative densities of saline and silicone shells are:

- Density of silicone elastomer = 1.10 to 1.17 g/cm³
- Density of silicone gel filler = 0.93 to 0.97 g/cm³
- Density of normal saline = 0.99 to 1.05 g/cm³

Because of the density difference between saline and the inner gel filler, even 0.1 to 0.2 g/cm³ may make a difference in weight and volume, especially in larger devices.

Additionally, one of the most common procedures in plastic surgery for breast reconstruction is the use of a temporary breast tissue expander followed later by the permanent placement of a breast implant in a 2-step process. According to 2012 statistics, silicone implants are the most common type of permanent implant selected by most plastic surgeons. In numerous studies, this approach has been shown to be safe, and produces high rates of aesthetic satisfaction and effective reconstruction after mastectomy. The 2-step reconstruction has been practiced for many years, with surgeons using tissue expanders to develop the breast, and later selecting an appropriate implant that best matches breast volume, height, and projection to fill the defect. A common practice within this surgery involves overexpanding the breast pocket with the tissue expander to create more volume than the final implant actually occupies. This action is taken to develop an expanded skin envelope and create a higher degree of lower pole stretch and ptosis of the permanent implant for improved aesthetics and reconstruction. With this in mind, the size of the pocket to be created is preoperatively assessed and determined by approximating the volume occupied by the empty tissue expander plus the added volume of saline anticipated to be injected into the expander. Although this is a clinically proven approach, this study aims to consider the issue that tissue expanders comprise more than the fluid injected into them. By simple visual inspection, an expander’s fill port and shell both occupy volume. To the best of the authors’ knowledge, this is only the second study to address the issue that these physical components occupy a significant volume in the breast pocket, with the first being a study of Mentor Corporation (Santa Barbara, CA, USA) products by McCue and colleagues in 2010. Although this unknown volume is compensated for by

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Fig. 1. (A, B) Silicone implants float when placed in a saline bath.

Fig. 2. (A, B) Saline implants hover in a saline water bath because they are isodense.
surgeons approximating the volume the total tissue expander occupies, the exact process is imprecise. The purpose of phase II of this study is to compare the actual volume of tissue expanders that are injected with specific amounts of fluid with both the volume of fluid injected into them and the potential final implants of similar stated volumes. Future applications of this research are numerous, given the high frequency that 2-step reconstructions are performed, the great emphasis on surgical accuracy, and the significant psychological and aesthetic impact it has on a large population of patients.

METHODS

For phase I of this study, serial weights of empty and saline-filled devices, specifically the Natrelle Style 68 and 168 textured devices, were compared. These devices were weighed both empty and filled with the clinical formulation of injectable normal saline. For the volumetric phase II study, volumes of both breast implants and tissue expanders were measured on 3 trial days, with each trial including 3 separate measurement tests of each expander and implant for a total of 9 trials. Twenty-three Natrelle silicone gel Style 20 high-profile type implants, which varied in volume from 120 to 800 mL, acted as controls. Six Style 133MV textured tissue expanders, which varied in maximal inflations from 250 to 700 mL, were also tested. The tissue expanders were first evacuated of any air via vacuum to prevent residual air, which is inherent in the production process, from affecting the experimental results. While structural change from overinflation was not an anticipated issue, the expanders were just filled to their stated capacity with a 50-mL syringe in 50-mL aliquots with distilled water. All tissue expanders were filled to their stated capacity to establish the lower bound of percent influence of their physical components. An apparatus, shown in Fig. 3, was constructed to measure the total volume of the tissue expanders and breast implants. First, a hole was drilled near the top of a large plastic container, which was placed on an elevated pedestal. A flexible Tygon tube was fitted and sealed into the hole with silicone caulk. The tubing was run downward toward a second container, which was placed on a calibrated balance. The first container was filled with distilled water over the top of the hole with the tube in it. The excess water drained out until the water level rested just below the hole’s opening. The apparatus was constructed in this manner so that any object placed into the upper container would cause all of the water displaced by the object to run down into the second container. The second container was dried and tared on the balance before each trial so that all water that entered it could be accurately measured. To measure either a tissue expander or implant, each was placed into the upper container and was allowed to fully submerge itself below the surface of the water. The mass of the displaced water and the temperature of the water were recorded, the latter because the density of water is very specific at given temperatures.

Computational Methodology

The calculation of the volume of the water displaced in each experiment by a tissue expander or implant was based on the mass and temperature of the displaced water. These amounts were calculated using Equation 1.

\[
\text{Density}_{\text{water}} = \frac{\text{Mass}_{\text{Total}}}{\text{Volume}_{\text{Total}}} \tag{1}\n\]

Equation 1 was solved for total volume to give Equation 2. The temperature of the water, which yielded its density, and the mass displaced by each object was measured during each trial.

\[
\text{Volume}_{\text{Total}} = \frac{\text{Mass}_{\text{water}}}{\text{Density}_{\text{Total}}} \tag{2}\n\]

Once the total volume of the object was known, Equation 3 was used to discover the effect of the port and shell of each tissue expander on the amount of water displaced.
This equation was solved for the volume of the physical components, which yielded Equation 4, which was possible as the total volume of each expander had been derived and the injected water had previously been measured and recorded.

\[
\text{Volume}_{\text{Physical Components}} = \text{Volume}_{\text{Total}} - \text{Volume}_{\text{Injected Water}}
\] (4)

Finally, the percent influence of the port and shell on the total volume of each tissue expander was calculated using Equation 5. Equation 6 outlines the additional percentage of volume created by the physical components of the expanders.

\[
\text{Percent influence} = \frac{((\text{Volume}_{\text{Injected Water}} - \text{Volume}_{\text{Total}}))}{\text{Volume}_{\text{Total}}} \times 100
\] (5)

\[
\text{Percent of additional volume} = \frac{((\text{Volume}_{\text{Total}} - \text{Volume}_{\text{Injected Water}}))}{\text{Volume}_{\text{Injected Water}}} \times 100
\] (6)

All data, figures, and tables were statistically analyzed and generated using Microsoft Excel 2008.

RESULTS

Phase I results evaluated a series of saline breast implant shells. Dry saline implant shells, depending on implant size and style, ranged from 10 to 40 g in weight. The more common implant sizes are shown in Table 1.

Tissue expanders, owing to their thick backing and infusion port, which weigh 10 g, adds 40 to 90 g depending on expander size (Fig. 4). For example, a 450-mL smooth saline implant filled to 450 mL of saline actually weighs 500 g and would require a 500-mL silicone implant to replace volume for volume (see Fig. 4), and likely more if the saline device is overfilled, as is common practice. Expanders weigh even more; for example, if a 400-mL Style 133MV expander is partially filled with 350 mL of saline, it actually weighs 425 g (see Fig. 4). The expander port weighs 10 g (see Fig. 4).

In phase II, the first experiment compared the stated volume of breast implants with their actual measured volume. The trials with the implants showed that the manufacturer’s stated volume for each implant was within 2.8 mL or less for every breast implant tested. Table 2 articulates these data in full detail. Moreover, the percent difference between the stated and measured volumes of each implant was 1% or less in every volume of implant.

In the same manner, tissue expanders were examined. The injected volume of distilled water, which represented injected saline, was compared with the total displaced volumes of the tissue expanders. Table 3 displays these results. The volume of injected solution and the total volume occupied by each tissue expander varied significantly across all volumes of tissue expanders examined. The difference between the fill volume of the smallest expander and actual displacement was 41.6 mL. This trend generally and steadily increased up to the largest expander of 700 mL, which differed by 72.9 mL between fill volume and total measured volume. The column in Table 3 describing the percent influence is of particular importance, as it shows how much the volume of the shell and fill port affected the total volume displaced by each tissue expander. Even at the largest injected volume of 700 mL, the percent of total volume affected by the expander’s physical components was 9.4%. Fig. 5 shows the trend of the implants’ fill volumes compared with the actual volumes they occupied. With the exception of the 500-mL tissue expander, the expander volumes increased in an almost exactly linear fashion. The trend line fitted to the tissue expander total volumes resulted in an \( r \) value of 0.99. The physical components of the 400-mL and 500-mL tissue expanders, as measured, occupied almost the same volume. However, the apparent deviation in linearity that this presumes is within 2 standard deviations of the regression line for each measured tissue expander.

Finally, Fig. 6 and Table 4 demonstrate the difference between the measured volume displaced by each breast implant and that of a corresponding tissue expander, which was filled to the same volume as an implant. Fig. 6 articulates that there is a significant difference between the two, and that the expander’s displaced volume greatly

<table>
<thead>
<tr>
<th>Table 1</th>
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</thead>
<tbody>
<tr>
<td><strong>Weights of varying saline implant shells</strong></td>
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<tr>
<td><strong>Volume (mL)</strong></td>
</tr>
<tr>
<td>270</td>
</tr>
<tr>
<td>300</td>
</tr>
<tr>
<td>330</td>
</tr>
<tr>
<td>360</td>
</tr>
<tr>
<td>420</td>
</tr>
<tr>
<td>450</td>
</tr>
<tr>
<td>500</td>
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</table>
exceeds the volume of each associated implant. For the smallest tissue expander and implant paring, the tissue expander occupied an additional 58.5 mL. This trend continued up to the largest tissue expander, which displaced an extra 71.4 mL of fluid compared with its corresponding implant.

**DISCUSSION**

The main findings of this 2-phase study were:

- The overall weight of a saline breast implant or tissue expander is significantly greater than the instilled volume alone, and in fact averages 1 or 2 implant sizes larger in volume than the instilled volume alone.
- Current expanders add even more weight to the overall device because of its thicker backing and metal port.
- There are differences in physical properties between saline and silicone.
- Saline implant shells can add 5% to 10% to the overall weight of the implant because saline devices are filled into an empty shell, whereas the factory measurements of weight and displacement of silicone devices include their inherent shell weight.
- Displaced volumes of physical components of tissue expanders had a significant impact on the total volume they occupy in comparison with the instilled saline alone.
- Displaced volumes of water are similar to weight differentials.

It is clear that saline implants weigh and displace significantly more volume than most surgeons recognize. After inspection of the results presented here, it can clearly be observed
Table 2
Stated and average measured volume of breast implants

<table>
<thead>
<tr>
<th>Stated Implant Volume (mL)</th>
<th>Average Displacement of Implant (mL)</th>
<th>Standard Deviation</th>
<th>Average Difference Between Stated and Measured Volumes (mL)</th>
<th>Percent Influence of Difference (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>120</td>
<td>120.2</td>
<td>2.78</td>
<td>0.2</td>
<td>0.2</td>
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<tr>
<td>140</td>
<td>139.7</td>
<td>2.99</td>
<td>0.3</td>
<td>0.2</td>
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<td>160</td>
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<td>2.66</td>
<td>0.8</td>
<td>0.5</td>
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<td>180</td>
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<td>3.12</td>
<td>1.2</td>
<td>0.7</td>
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<td>200</td>
<td>200.3</td>
<td>2.23</td>
<td>0.3</td>
<td>0.1</td>
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<tr>
<td>230</td>
<td>232.4</td>
<td>3.33</td>
<td>2.4</td>
<td>1.0</td>
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<td>260</td>
<td>258.8</td>
<td>2.99</td>
<td>1.2</td>
<td>0.5</td>
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<tr>
<td>280</td>
<td>280.5</td>
<td>3.33</td>
<td>0.5</td>
<td>0.2</td>
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<tr>
<td>300</td>
<td>299.4</td>
<td>3.60</td>
<td>0.6</td>
<td>0.2</td>
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<td>4.25</td>
<td>1.2</td>
<td>0.4</td>
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<td>2.0</td>
<td>0.6</td>
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<td>375</td>
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<td>4.48</td>
<td>1.1</td>
<td>0.3</td>
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<td>402.1</td>
<td>2.02</td>
<td>2.1</td>
<td>0.5</td>
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<td>425</td>
<td>427.8</td>
<td>2.00</td>
<td>2.8</td>
<td>0.7</td>
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<td>450</td>
<td>452.2</td>
<td>4.36</td>
<td>2.2</td>
<td>0.5</td>
</tr>
<tr>
<td>475</td>
<td>477.3</td>
<td>3.52</td>
<td>2.3</td>
<td>0.5</td>
</tr>
<tr>
<td>500</td>
<td>500.8</td>
<td>2.90</td>
<td>0.8</td>
<td>0.2</td>
</tr>
<tr>
<td>550</td>
<td>551.3</td>
<td>3.70</td>
<td>1.3</td>
<td>0.2</td>
</tr>
<tr>
<td>600</td>
<td>600.4</td>
<td>3.96</td>
<td>0.4</td>
<td>0.1</td>
</tr>
<tr>
<td>650</td>
<td>651.6</td>
<td>3.75</td>
<td>1.6</td>
<td>0.2</td>
</tr>
<tr>
<td>700</td>
<td>701.5</td>
<td>4.13</td>
<td>1.5</td>
<td>0.2</td>
</tr>
<tr>
<td>750</td>
<td>751.2</td>
<td>3.73</td>
<td>1.2</td>
<td>0.2</td>
</tr>
<tr>
<td>800</td>
<td>802.8</td>
<td>4.66</td>
<td>2.8</td>
<td>0.4</td>
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</table>

Data articulate the close match between the stated volume of each implant and its corresponding measured volume.

Table 3
Influence of physical components of tissue expanders

<table>
<thead>
<tr>
<th>Tissue Injected Volume (mL)</th>
<th>Volume Displaced by Tissue Expander (mL)</th>
<th>Standard Deviation</th>
<th>Average Difference of Stated vs Observed Expanders (mL)</th>
<th>Percent Influence of Physical Components on Total Volume (%)</th>
<th>Additional Percentage of Volume Created (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>250</td>
<td>291.6</td>
<td>2.72</td>
<td>41.6</td>
<td>14.3</td>
<td>16.7</td>
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<tr>
<td>300</td>
<td>357.9</td>
<td>3.16</td>
<td>57.9</td>
<td>16.2</td>
<td>19.3</td>
</tr>
<tr>
<td>400</td>
<td>467.1</td>
<td>3.60</td>
<td>67.1</td>
<td>14.4</td>
<td>16.8</td>
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<tr>
<td>500</td>
<td>564.2</td>
<td>2.44</td>
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<td>11.4</td>
<td>12.8</td>
</tr>
<tr>
<td>600</td>
<td>670.0</td>
<td>2.99</td>
<td>70.0</td>
<td>10.4</td>
<td>11.7</td>
</tr>
<tr>
<td>700</td>
<td>772.9</td>
<td>4.32</td>
<td>72.9</td>
<td>9.4</td>
<td>10.4</td>
</tr>
</tbody>
</table>

Significant difference was observed between expander fill volume and displaced volume. Furthermore, there is a striking effect of the physical components on the total volume of each expander, both in their percent influence on total volume and the additional volume that they create.
that the fill port and shell dramatically affect the total volume of the tissue expanders, and must be taken into account by the surgeon when developing the breast for future placement of a permanent implant. For all of the different tissue expanders measured, the port and shell added significant volume. The concept that the physical components of expanders possess noteworthy volume, while previously hypothesized or clinically estimated, now has a concrete value for

![Graph](https://via.placeholder.com/150)

**Fig. 5.** Comparison of tissue expander fill volume and average measured volume. The key feature depicted is the difference between the fill volume of each tissue expander and the total measured volume of the expander. The difference is due to the tissue expanders' physical components. The linear trend line fitted to the “Measured Volume of Tissue Expander” bars (red) had an $r$ value of 0.99, which showed high statistical correlation.

![Graph](https://via.placeholder.com/150)

**Fig. 6.** Comparison of tissue expander fill volume, actual volume, and corresponding implant volume. The graph shows the volume theoretically created with a tissue expander (blue), the volume actually created by the same tissue expander (red), and the volume occupied by a corresponding permanent implant (green).
the Allergan model measured. These data will allow for precise assessment of the volume these tissue expanders create for a corresponding amount of injected saline used for inflation. The knowledge of the volume created will further allow for accurate matching of an implant into the created breast, and should remove a significant amount of previously associated approximation. In addition, although the implants measured in this study were not anatomically shaped, the issue of understanding the exact volume created by an expander comes under sharp focus when considering anatomic implants, including the Allergan 410 textured implant. Because these types of implants require a “hand-in-glove” fit with the volume created by the preceding expander, it is paramount that these 2 volumes correlate precisely to prevent implant rotation or malpositioning.\textsuperscript{15} Clearly the physical components of tissue expanders increase the total pocket size beyond the volume injected. Therefore, not taking this into account will necessitate either additional procedures during implant placement, such as a capsulorrhaphy to decrease or restructure the final pocket size,\textsuperscript{16} or require an increase in the size of the planned implant needed to fill the developed volume. In addition, many surgeons are transitioning from a volumetric-only view of implants to a “bio-dimensional” or “tissue-based planning” approach. This approach takes into consideration the actual implant dimensions, with breast and implant base width, height, and projection now coming into play. When considering breast reconstruction with shaped implants, surgeons must give particular consideration to using shorter height devices than the expander height, the same or a slightly more narrow expander width compared with the final shaped device, or even underfilling the expander at least by 50 to 75 mL to make up for the shell and port weight and certainly avoiding overexpansion.

In evaluating these results, it is important to note that the physical components of the expander had less of a percent influence on the total volume as the expander size increased. This result was an expected one because there was a significant increase in injected fluid volume for each increase in tissue expander capacity. Compared with the port and shell size, which increased only to minor degrees, there was a significant comparative increase in fluid volume, which caused the percent influence of the physical components to trend downward with increasing expander inflation size. However, whereas the percentage of total volume that was affected by the port and shell was greater in the small-sized tissue expanders, a greater volumetric impact was seen in the larger-sized expanders. Both of these findings are significant clinically because they affect the sizing of tissue expanders differently, and must be taken into account.

The results of this study can further be applied to 2 additional practices associated with the 2-step reconstruction after mastectomy. The first concerns the overexpansion of submuscular tissue for the breast pocket. This approach has become common for developing the breast pocket for better ptosis of the final implant. This aspect is especially important if the contralateral breast is devoid of surgery, and matching native anatomy is of the utmost priority. Depending on the surgeon’s preference, the volume created by the tissue expander may exceed the final implant volume by up to 20% to 30%.\textsuperscript{1,5,8,17,18} However, given that this study shows that the physical components provide an additional 10.4% to 19.3% of volume, the developed breast pocket could be significantly larger than anticipated if they are not accounted for. Therefore, it is crucial to take these findings into

<table>
<thead>
<tr>
<th>Fill Volume of Tissue Expander (mL)</th>
<th>Volume of Tissue Expander (mL)</th>
<th>Average Measured Volume of Corresponding Implant (mL)</th>
<th>Difference Between Average Measured Implant and Tissue Expander (mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td>357.9</td>
<td>299.4</td>
<td>58.5</td>
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<tr>
<td>700</td>
<td>772.9</td>
<td>701.5</td>
<td>71.4</td>
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</tbody>
</table>

Data indicate a significant difference between the volume created for the breast pocket and the volume occupied by the permanent implant.
consideration when inflating the expander, and also during selection of a final implant.

Additionally, tissue expander volume displacement correlates with expander weight differentials and is nearly identical to volume displacement of water with the proximity of volume and density (1 mL = \( \sim 1 \) g). Because of the expander’s thick backing and infusion port, which weigh 10 g, the total added weight is 40 to 90 g depending on the expander size (see Fig. 4). For example, if a 400-mL Style 133FV expander is partially filled with 350 mL of saline it actually weighs 425 g (see Fig. 4). The expander port alone weighs 10 g (see Fig. 4).

As an example of standard saline devices, a 450-mL smooth saline implant filled with 450 mL of saline, has a total actual weight of 500 g. Volume for volume it would take a 500-mL silicone implant to replace a saline device filled to 450 mL (see Fig. 4), and incrementally more if the saline device is overfilled, as is common practice.

Furthermore, the common use of AlloDerm, other acellular dermal matrices, or biological scaffolds for breast reconstruction is also affected by these findings. AlloDerm, which is an acellular dermal matrix that is free of antigens, has become an important tool for plastic surgeons. Many investigators have provided approaches for its use and for assessment of the amount of dermal matrix needed for inferior pole coverage for implants, sling creation for an implant, or a combination of these and other additional applications. In fact, Haddock and Levine have previously created equations to compare fill volume and AlloDerm surface area and height. Given the significant consideration currently being given to this subject, it is essential to also consider the additional volume created by the physical components of the tissue expander. This additional volume also then affects the surface area that the AlloDerm will need to cover and support. Although the assessment of the added surface area created by the physical components of expanders was beyond the scope of this study, the conclusion can be drawn that the difference is not inconsequential.

While these results prove that the shell and port of tissue expanders dramatically affect their total volumes across the board, they also present 2 interesting fragments of data, the first of which is that the volumes displaced by the breast implants were not precise according to the manufacturer’s stated volumes. This variability was hypothesized to be due to slight variability between implants produced, and is consistent with prior data analysis on the variability between production batches. However, the overall variability observed was statistically insignificant. The second observation is that the rate at which the port and shell affected the total volume of the tissue expanders did not follow an exact logarithmic scale as was initially suspected. The 400-mL and 500-mL expanders had almost identical physical component volumes. However, as stated previously, the results for these 2 tissue expander volumes fell within 2 standard deviations of the regression line fitted from the smallest to largest tissue expander.

Through these experiments, it is evident that there is a significant need for future study in this arena. This study assessed only one specific style of tissue expander and compared it with one style of implant from the same company. Additional testing of multiple tissue expanders and implants of the same sizes needs to be done to confirm these findings. However, variability between batch productions is minimal, so an initial conclusion can be drawn that these findings are indeed accurate. Furthermore, although the notion that the physical components of tissue expanders do indeed occupy statistically significant volume compared with the total volume of inflated tissue expanders, the exact volumes found in this study are not necessarily applicable across styles of tissue expanders, much less between companies. Initial support of this is evident from the study of Mentor products by McCue and colleagues in 2010. Because of the variability in the size of ports and shells for different styles of tissue expanders, it is apparent that today’s plastic surgeons must have a database from which they can quickly reference the impact of the physical components of tissue expanders to make appropriate and precise adjustments when inflating an expander to develop a breast in both the clinic and operating room settings. This pilot study provides a stepping-stone for future investigation. Ultimately, the most important goal to be achieved by creating a database is that patients might have better surgical results and outcomes. With an increasing number of women choosing breast reconstruction because of either mastectomy after cancer occurrence or prophylactic mastectomies, adding proficiency and accuracy to this specific surgical approach is essential. Early and superior breast reconstruction has a significant influence on patient psychology and sexuality. A future database would simplify reconstruction, enhance aesthetics, reduce complication rates, and thereby help women cope and persevere after surviving a difficult health ordeal.

Lastly, as a result of this research, the authors hope that surgeons will weigh or displace removed expanders or saline implants, document these
data, and use them to direct the choice of the new devices. With the high demand for aesthetics and quality outcomes in both breast revision and reconstruction, surgeons will require immediate access to this additional knowledge to help choose the best option and create the best possible symmetric outcome for every patient.

**Materials used for volumetric displacement studies**

- 1000-mL glass beaker
- Balance (accurate to nearest gram)
- Flexible Tygon tubing
- 2000-mL plastic beaker
- Silicone caulk
- Twenty-three silicone gel Style 20 (Allergan, Inc, Irvine, CA, USA) high-profile type implants (120–800 mL)
- Six Style 133MV tissue expanders (Allergan) (maximal inflations ranging from 250 to 700 mL)
- Distilled water

**Materials used for weight measurement studies**

- Standard operating room scale
- Smooth saline Style 68 Implants
- Style 133MV tissue expanders

**DISCLOSURE**

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**Materials used for volumetric displacement studies**

**Materials used for weight measurement studies**

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**REFERENCES**


