Annals of Plastic and Reconstructive Surgery

Research Article
Published: 14 Oct, 2019

Are Breast Implant Manufacturers' Volume Labels Scientifically Obsolete?

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Abstract

The manufacture of breast implants is surrounded by secrecy and proprietary technologies, with resultant differences among various brands. Upon choosing implants for a breast augmentation patient, we encountered the unexpected "fact" that two round implants produced by different manufacturers, with seemingly same advertised diameter and projection, had different claimed volumes.

We set to make sense of this finding and compared the catalogues from two manufacturers to the theoretical calculations based on the presumed shape of the implants, whether a segment of a sphere or an oblate spheroid.

While both manufacturers had labels "close" to the calculated volume, one of them was consistently more in-range. Yet, the differences that clearly exist from labeled volumes prove beyond doubt, that the breast implants manufacturers volume labels are scientifically obsolete, and should not be the primary factor in the preoperative decision-making.

Keywords: Breast implants; Preoperative assessment; Breast augmentation

Introduction

When choosing implants for a breast augmentation patient, surgeons may be faced with the unexpected "fact" that two round implants produced by different manufacturers, with seemingly same advertised diameter and projection, have different claimed volumes.

Upon a closer examination of the catalogues, multiple discrepancies could be identified.

- A 160 cc (Moderate) Eurosilicone implant matched the dimensions of a 175 cc (Moderate Plus) Mentor implant with a diameter of 10 cm and a projection of 3.1 cm.
- A 240 cc (Moderate) Eurosilicone implant matched the dimensions of a 275 cc (Moderate Plus) Mentor implant with a diameter of 11.7 cm and a projection of 3.5 cm.
- A 650 cc (Moderate) Eurosilicone implant matched the dimensions of a 700 cc (Moderate Plus) Mentor implant with a diameter of 15.8 cm and a projection of 4.9 cm.

The implications of this situation can be significant in terms of implant-selection, in particular for the patient, when what only matters for her is the implant's volume. In order to make sense of this finding, we set to compare the catalogues of two breast implant manufacturers and verify the correlation of breast implant measurements.

Methods

Comparing implants by different manufacturers is not an easy task when they offer different ranges of shapes, diameters, projections, texture, and feel.

To that end, and for simplicity, we chose to compare smooth, round implants of two well known manufacturers in Europe and North America.

Round implants are shaped as segments of a sphere, with a flat posterior surface, and a convex anterior surface.

The concept of a round implant implies that they are designed as segments of a perfect sphere. Subsequently, the volume of a segment of a sphere can be obtained using the formula:

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Received Date: *16 Sep 2019*
Accepted Date*: 05 Oct 2019*
Published Date*: 14 Oct 2019*

Citation:
Chahine FM, Habr N, Atiyeh B. Are Breast Implant Manufacturers' Volume Labels Scientifically Obsolete?. Ann Plast Reconstr Surg. 2019; 3(4): 1039.

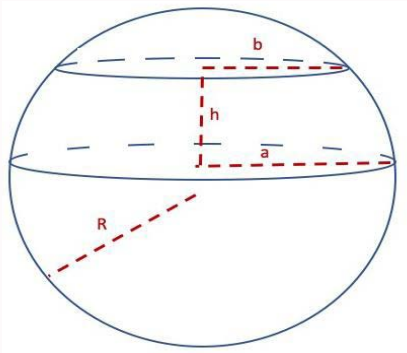

Figure 1: A spherical segment is a three-dimensional geometrical object that is obtained with a pair of two parallel planes intersecting a sphere with radius R.
This creates two circles with radii b and a, respectively. The height of the segment h is the distance between the bases.

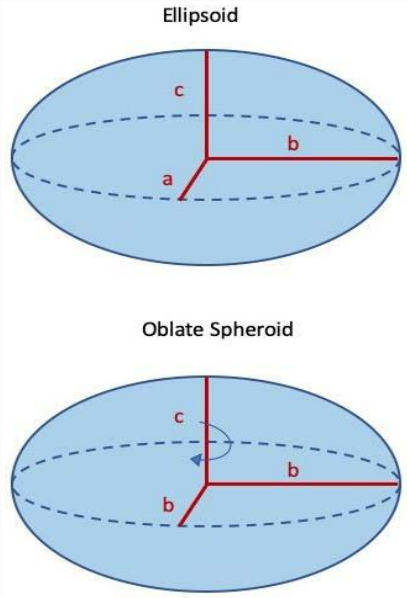

Figure 2: An oblate spheroid is an ellipsoid rotated about axis c.

$$V = \frac{1}{6}\Pi h(3a^2 + 3b^2 + h^2)$$

Where a spherical segment is a three-dimensional geometrical object that is obtained with a pair of two parallel planes intersecting a sphere with radius R.

This creates two circles with radii b and a, respectively. The height of the segment h is the distance between the bases (Figure 1). For breast implants, the value could be the radius of the implant, b is considered zero, and h is the projection.

However, a close inspection of round breast implants may suggest that they are not fashioned from perfect spheres, but rather from an ellipse. If the ellipse is rotated about its semi-major axis, the result is a prolate (elongated) spheroid, similar in shape to an American football. If the ellipse is rotated about its semi-minor axis, the result is an oblate (flattened) spheroid [1,2] (Figure 2).

A sphere may result when the generating ellipse is a circle.

As such, the implant would be fashioned as half of an oblate spheroid, and its volume is calculated using the formula:

$$V = \frac{\frac{4}{3}\Pi b^2.c}{2}$$

where b is the semi-major axis, while c is the semi-minor axis.

These two formulas allow us to calculate the theoretical volume of an implant. Furthermore, the ratio of the calculated volume to the labelled volume indicates the fill percentage of the implant.

We compared round smooth breast implants in the catalogues from Mentor and Eurosilicone.

Results

Looking back at the comparisons made earlier while

- A 160 cc (Moderate) Eurosilicone implant with a diameter of 10 cm and a projection of 3.1 cm matched the dimensions of a 175 cc (Moderate Plus) Mentor implant, yet the matching calculated volume of a segment of a sphere would be 137.3 cc, and that of an oblate spheroid 162.3 cc.
- A 240 cc (Moderate) Eurosilicone implant with a diameter of 11.7 cm and a projection of 3.5 cm matched the dimensions of a 275 cc (Moderate Plus) Mentor implant, yet the matching calculated volume of a segment of a sphere would be 210.6 cc, and that of an oblate spheroid 250.9 cc.
- A 650 cc (Moderate) Eurosilicone implant with a diameter of 15.8 cm and a projection of 4.9 cm matched the dimensions of a 700 cc (Moderate Plus) Mentor implant, yet the matching calculated volume of a segment of a sphere would be 542 cc, and that of an oblate spheroid 640.5 cc.

Table 1a: Comparison of labeled and calculated volumes for mentor moderate profile implants (SS: Segment of Sphere calculated theoretical volume; OS: Oblate Spheroid calculated theoretical volume).

Diameter (cm)	Projection (cm)	Labeled Volume (mL)	SS Volume (mL)	Fill	OS volume (mL)	Fill
10	2.2	125	92	74%	115.2	92%
10.3	2.3	150	102.2	68%	127.8	85%
11.2	2.4	175	125.5	72%	157.6	90%
11.7	2.5	200	142.6	71%	179.2	90%
12.2	2.6	225	161.2	72%	202.6	90%
12.3	2.8	250	177.8	71%	221.8	89%
13.2	2.9	275	211.2	77%	264.6	96%
13.5	3	300	228.8	76%	286.3	95%
13.9	3	325	241.8	74%	303.5	93%
14.2	3.1	350	261.1	75%	327.3	94%
14.4	3.2	375	277.7	74%	347.4	93%
14.5	3.2	400	281.4	70%	352.3	88%
14.9	3.4	450	317	70%	395.2	88%
15.2	3.6	500	351.1	70%	435.5	87%
15.9	3.6	550	381.8	69%	476.5	87%
16.5	3.7	600	422.1	70%	527.4	88%
17.4	3.9	700	494.7	71%	618.2	88%
18.2	4.1	800	569.4	71%	711.1	89%
Moderate Profile			average	72%		90%

Table 1b: Comparison of labeled and calculated volumes for mentor moderate plus profile implants (SS: Segment of Sphere calculated theoretical volume; OS: Oblate Spheroid calculated theoretical volume).

Diameter (cm)	Projection (cm)	Labeled Volume (mL)	SS Volume (mL)	Fill	OS volume (mL)	Fill
8.9	2.8	125	98.6	79%	116.1	93%
9.5	2.9	150	115.5	77%	137	91%
10	3.1	175	137.3	78%	162.3	93%
10.5	3.2	200	155.7	78%	184.7	92%
10.9	3.3	225	172.8	77%	205.3	91%
11.3	3.4	250	191.1	76%	227.3	91%
11.7	3.5	275	210.6	77%	250.9	91%
12	3.6	300	228	76%	271.4	90%
12.3	3.8	325	254.5	78%	301	93%
12.5	3.9	350	270.4	77%	319.1	91%
12.8	4	375	290.9	78%	343.1	92%
13.1	4	400	303.1	76%	359.4	90%
13.6	4.2	450	343.9	76%	406.7	90%
14.1	4.3	500	377.3	75%	447.6	90%
14.6	4.5	550	424.4	77%	502.2	91%
15	4.6	600	457.4	76%	541.9	90%
15.8	4.9	700	542	77%	640.5	91%
16.5	5.1	800	614.7	77%	727	91%
Moderate Plus Profile			average	77%		91%

Table 1c: Comparison of labeled and calculated volumes for mentor high profile implants (SS: Segment of Sphere calculated theoretical volume; OS: Oblate Spheroid calculated theoretical volume).

Diameter (cm)	Projection (cm)	Labeled Volume (mL)	SS Volume (mL)	Fill	OS volume (mL)	Fill
8.3	3.5	125	117.1	94%	126.2	101%
8.8	3.7	150	139	93%	150	100%
9.3	3.9	175	163.5	93%	176.6	101%
9.7	4	200	181.3	91%	197.1	99%
10.1	4.2	225	207	92%	224.3	100%
10.5	4.3	250	227.8	91%	248.2	99%
10.8	4.4	275	246.1	90%	268.7	98%
11.1	4.5	300	265.4	88%	290.3	97%
11.4	4.6	325	285.7	88%	313	96%
11.7	4.8	350	315.9	90%	344	98%
12	4.8	375	329.3	88%	361.9	97%
12.2	5	400	357.7	89%	389.7	97%
12.5	5	425	372.2	88%	409.1	96%
12.8	5.1	450	397.6	88%	437.5	97%
13.2	5.3	500	440.6	88%	483.5	97%
13.6	5.5	550	486.6	88%	532.6	97%
14	5.6	600	523	87%	574.7	96%
14.4	5.7	650	561.1	86%	618.9	95%
14.8	5.8	700	601.1	86%	665.2	95%
15.5	6	800	679.2	85%	754.8	94%
High Profile			average	89%		97%

Table 1d: Comparison of labeled and calculated volumes for mentor ultra high profile implants (SS: Segment of Sphere calculated theoretical volume; OS: Oblate Spheroid calculated theoretical volume).

Diameter (cm)	Projection (cm)	Labeled Volume (mL)	SS Volume (mL)	Fill	OS volume (mL)	Fill
8.2	4.3	160	155.2	97%	151.4	95%
8.4	4.4	185	166.5	90%	162.6	88%
8.7	4.5	215	181.5	84%	178.3	83%
9	4.7	240	203.9	85%	199.3	83%
9.3	4.8	270	220.9	82%	217.4	81%
9.7	5	295	250.2	85%	246.3	84%
9.8	5.1	320	261.8	82%	256.5	80%
10.1	5.2	350	281.9	81%	277.7	79%
10.4	5.3	375	303.1	81%	300.2	80%
10.6	5.4	400	320.7	80%	317.7	79%
10.9	5.6	430	353.2	82%	348.4	81%
11.2	5.7	455	377.7	83%	374.4	82%
11.4	5.8	480	398.2	83%	394.7	82%
12	6.1	535	463.8	87%	459.9	86%
12.5	6.3	590	517.5	88%	515.4	87%
Ultra High Profile			average	86%		83%

Table 2a: Comparison of labeled and calculated volumes for Eurosilicone low profile implants (SS: Segment of Sphere calculated theoretical volume; OS: Oblate Spheroid calculated theoretical volume).

Diameter (cm)	Projection (cm)	Labeled Volume (mL)	SS Volume (mL)	Fill	OS volume (mL)	Fill
9.6	2	100	76.6	77%	96.5	97%
9.7	2.4	120	95.9	80%	118.2	99%
10.2	2.5	140	110.3	79%	136.2	97%
10.4	2.8	160	130.4	82%	158.6	99%
10.9	2.9	180	148.1	82%	180.4	100%
11.6	2.8	200	159.5	80%	197.3	99%
11.8	3	220	178.2	81%	218.7	99%
12	3.1	240	190.9	80%	233.7	97%
12.2	3.3	260	211.7	81%	257.2	99%
12.5	3.3	280	221.3	79%	270	96%
12.9	3.4	300	242.8	81%	296.2	99%
13.2	3.5	325	261.9	81%	319.3	98%
13.5	3.6	350	282.1	81%	343.5	98%
13.8	3.7	375	303.2	81%	368.9	98%
14.2	3.7	400	319.5	80%	390.6	98%
14.7	3.8	450	351.2	78%	429.9	96%
15.3	4	500	401.2	80%	490.3	98%
Low Profile			average	80%		98%

From these 3 observations we can note that the labeled Eurosilicone implants volumes are closer to the calculated volumes.

Looking at the Table 1 and 2, we notice that the labeled implants volumes approximate more those calculated from the formula for oblate spheroids.

The fill percentage for Mentor ranged from 68% to 99% when

Table 2b: Comparison of labeled and calculated volumes for Eurosilicone medium profile implants (SS: Segment of Sphere calculated theoretical volume; OS: Oblate Spheroid calculated theoretical volume).

Diameter (cm)	Projection (cm)	Labeled Volume (mL)	SS Volume (mL)	Fill	OS volume (mL)	Fill
9	2.9	120	105	88%	123	102%
9.3	3.2	140	125.8	90%	144.9	104%
10	3.1	160	137.3	86%	162.3	101%
10.6	3.2	180	158.4	88%	188.3	105%
11.1	3.3	200	178.5	89%	212.9	106%
11.5	3.2	220	183.3	83%	221.6	101%
11.7	3.5	240	210.6	88%	250.9	105%
11.9	3.6	260	224.6	86%	266.9	103%
12.3	3.7	280	246.3	88%	293.1	105%
12.4	3.9	300	266.5	89%	314	105%
12.7	4	325	286.9	88%	337.8	104%
13	4	350	299	85%	354	101%
13.3	4.2	375	330.5	88%	389	104%
13.7	4.2	400	348.4	87%	412.8	103%
14.1	4.4	450	388.1	86%	458	102%
14.5	4.6	500	430.8	86%	506.4	101%
15	4.8	550	482	88%	565.5	103%
15.8	4.5	600	488.9	81%	588.2	98%
15.8	4.9	650	542	83%	640.5	99%
15.8	5.4	700	611.8	87%	705.8	101%
15.9	5.8	750	678	90%	767.8	102%
15.8	6	800	701.3	88%	784.3	98%
Moderate Profile			average	87%		102%

Table 2c: Comparison of labeled and calculated volumes for Eurosilicone high profile implants (SS: Segment of Sphere calculated theoretical volume; OS: Oblate Spheroid calculated theoretical volume).

Diameter (cm)	Projection (cm)	Labeled Volume (mL)	SS Volume (mL)	Fill	OS volume (mL)	Fill
8.9	2.8	120	98.6	82%	116.1	97%
8.8	3.2	140	114.5	82%	129.8	93%
9.3	3.3	160	130.9	82%	149.4	93%
9.5	3.6	180	152	84%	170.1	95%
9.9	3.7	200	168.9	84%	189.9	95%
10.3	3.7	220	180.7	82%	205.5	93%
10.5	3.9	240	199.9	83%	225.1	94%
10.7	4.1	260	220.4	85%	245.8	95%
10.9	4.3	280	242.3	87%	267.5	96%
11.1	4.4	300	257.5	86%	283.9	95%
11.4	4.5	325	277.4	85%	306.2	94%
11.7	4.7	350	307	88%	336.9	96%
11.7	4.9	375	325	87%	351.2	94%
12.2	4.9	400	348	87%	381.9	95%
12.5	5.3	450	403.2	90%	433.6	96%
12.6	5.8	500	463.8	93%	482.1	96%
High Profile			average	85%		95%

Table 2d: Comparison of labeled and calculated volumes for Eurosilicone extra high profile implants (SS: Segment of Sphere calculated theoretical volume; OS: Oblate Spheroid calculated theoretical volume).

Diameter (cm)	Projection (cm)	Labeled Volume (mL)	SS Volume (mL)	Fill	OS volume (mL)	Fill
8	3.5	120	110.4	92%	117.3	98%
8.5	3.8	140	136.5	98%	143.8	103%
8.8	3.9	160	149.7	94%	158.1	99%
9.1	4.3	180	181.5	101%	186.4	104%
9.4	4.3	200	190.8	95%	198.9	99%
9.7	4.4	220	207.2	94%	216.8	99%
10.2	4.4	240	224.4	93%	239.7	100%
10.4	4.5	260	238.8	92%	254.8	98%
10.6	4.7	280	261.7	93%	276.5	99%
10.8	4.9	300	286	95%	299.3	100%
11	5.1	325	311.8	96%	323.1	99%
11.3	5.1	350	325.2	93%	341	97%
11.6	5.2	375	348.4	93%	366.4	98%
11.8	5.5	400	387.9	97%	401	100%
12.1	5.7	450	424.7	94%	437	97%
12.3	6.1	500	481.3	96%	483.2	97%
12.5	6.4	550	530	96%	523.6	95%
13.1	6.4	600	568.6	95%	575.1	96%
13.6	6.4	650	602.1	93%	619.8	95%
13.4	7.1	700	688	98%	667.5	95%
13.5	7.4	750	741.8	99%	706.2	94%
13.6	7.7	800	798.3	100%	745.7	93%
Extra High Profile			average	95%		98%

calculating segments of spheres, but is 79.4% to 101% when considered as oblate spheroids. Eurosilicone's fill percentage on the other hand ranged from 77% to 101% when calculating segments of spheres, but 92.7% to 106.4% when considered as oblate spheroids.

Discussion

Comparing labeled breast implants volumes among several manufacturers is not an intuitive idea, and as plastic surgeons we often need to use implants from various manufacturers.

The tables clearly show that there is no consistent difference between the labeled volume and the calculated volume in both manufacturers we chose to compare.

Due to lack of standardization in terms of breast implant projection labeling, it is understandable that different manufacturers may have different dimensions for various projections. Still, a thorough search of the literature on PubMed and Medline fails to reveal any insight as to such differences between breast implant manufacturers, or what it could signify.

However, the Eurosilicone catalogue does include a reference to fill percentage (without further explanation) of 85% for the Low Profile and High Profile, but goes up to 100% for the Medium and Extra High Profile implants.

Mentor catalogue on the other hand has no mention of fill percentage, and as such no further clarifications can be obtained.

Ideally however, catalogues from more manufacturers should be analyzed, and water submersion of the implants could be done to compare the labelled volumes and determine their accuracy. Nevertheless, judging from the differences between the calculated and the labeled volumes, these differences are rather small, and likely not clinically significant.

To that end, taking into account the facts that we revealed, the volume labeling can be misleading to both the surgeon and the patient when choosing implants from different manufacturers.

Moreover, of the many algorithms available for selecting breast implants such as the TEPID [3] or the high-five method of Tebbets [4], and the Atiyeh method [5], all rely on breast measurements and on soft tissue envelope to determine the optimal breast implant size for a patient. Yet, patients seeking augmentation mammaplasty often present to our clinics requesting a certain implant size that their friends have had, and that they were satisfied with.

It should be noted though that final breast size and shape following augmentation mammoplasty is influenced by many factors and not only by the size and shape of a given implant. Position of the implant on the chest wall and its relationship to the nipple areola complex is of prime importance. The position of the infra-mammary fold should not be overlooked either. Moreover, late capsular contracture has a definite impact on final breast shape, volume and projection. It is logical to assume that the less the fill volume percentage, the more will be the change in shape and projection. Any liquid filled deformable container will take a spherical shape when subjected to compressive forces. As a corollary, it is thus logical to assume also that it may be advisable to select implants with the highest fill volume percentage and with the least deformable fill material.

As already stated in a recent publication, "There is no one implant that is appropriate for every patient. This makes breast augmentation both an art and a science" [5]. As such, there is no single implant volume that fits a single patient, but rather a range. Therefore, if a patient requests a specific volume, this may not necessarily affect the final result, provided the patient's anatomic measurements are respected. Clearly, the differences that exist from labeled volumes prove beyond doubt, that the breast implant manufacturer's volume labels are scientifically obsolete, and should not factor in the preoperative decision-making.

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