



Hybrid Breast Augmentation: A Reliable Formula for Preoperative Assessment of Fat Graft Volume Based on Implant Volume and Projection

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Abstract

Background: Autogenous fat grafting (AFG) is an established technique used as an adjunct to breast augmentation (BA) to redesign breast shape. Surgeons often use experience and intuition to estimate AFG volume, which can result in incorrect assessment of donor areas and unnecessary fat removal.

Objectives: This aim of this study was to develop a method based on a mathematical formula, which utilizes implant volume and projection to predict AFG volume.

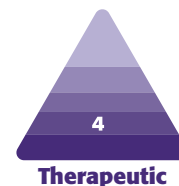
Methods: Thirty patients (60 breasts) underwent primary hybrid BA. A software package (SketchUp) was used to simulate 3-dimensional AFG and implant volumes, which in turn were used to develop an equation for estimating AFG volume according to 3 different implant projections. The results for each group were compared, via Pearson's correlation coefficient, with the results of the clinical series.

Results: All patients received Motiva Ergonomix SmoothSilk/SilkSurface implants, ranging in volume from 175 to 355 cc (mean, 265 cc), as well as an average AFG volume of 79.2 cc/breast (range, 50–110 cc). Twenty-nine patients (96.6%) were either very satisfied or satisfied during a mean follow-up of 18 months (range, 6–28 months). A high correlation was observed between the AFG performed in the cohort and predictions obtained from the formula ($r = 0.938$, $P < 0.001$).

Conclusions: The AFG volume in hybrid BA procedures can be estimated utilizing measurements based on implant volume/projection. This low-cost method can be applied to guide surgical decision-making in patients who are candidates for BA.

Level of Evidence: 4

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Breast augmentation (BA) with silicone gel implants is one of the most common plastic surgery procedures performed worldwide;^{1,2} since the first introduction of these implants in the 1960s, techniques have advanced.³⁻⁷ The subfascial (SF) plane technique was introduced in the 1990s,^{8,9} with the fascia offering an alternative pocket with supplementary implant coverage and avoiding the limitations of the submuscular (SM) position.⁸⁻²² In our previous experience,^{14,16,21,22} and as other authors have observed,^{8-11,15,18,19} the SF technique provides faster postoperative recovery than an entirely SM pocket in selected cases, without breast animation when the pectoral muscle is contracted.

Recently, autogenous fat grafting (AFG) has been indicated as a technique associated with BA to improve silicone coverage, redesign the shape of the breast, and treat local defects.^{21,23-28} Initially denoted composite BA,^{24,25} the main benefit of what is now known as hybrid BA (HBA) was the ability to reshape the upper breast quadrants by reducing upper pole cleft and obtain upper pole fullness with a natural transition.²¹ Besides AFG associated with silicone, some authors have also described utilizing AFG in large volumes to perform BA without implants.^{29,30}

Plastic surgeons normally estimate AFG volume based on their experience and intuition; inaccurate predictions of this volume could result in incorrect assessment of donor areas and even unnecessary fat removal. So far no studies have proposed methods or formulas for estimating the volume of fat to be grafted in association with BA. Although several studies have examined selection of donor sites, AFG preparation, and grafting techniques,³¹⁻³³ a formula to quantify the volume of fat needed to complement the silicone implant volume has not yet been developed. This study suggests a new method utilizing a formula based on implant projection and volume to predict an estimated volume of AFG in HBA in order to fill the superior breast poles and achieve an anatomic composite breast.

METHODS

Clinical Study

A retrospective chart review of primary/secondary HBA procedures was performed. All study participants gave written informed consent, and the study was conducted in accordance with the provisions of the Declaration of Helsinki. All surgeries were conducted at a single outpatient facility by 1 surgeon (A.M.M.) over a period spanning nearly 2 years (June 2017–April 2019). All patients were candidates for BA, and data on patient age, body mass index (BMI), incision, and implant-related data (surface, shape, volume, and position) were also collected for each patient. Periods selected for analysis included less than 10 days, 1, 3, 6, and 12 months, and then at 2-year intervals postprocedure. Patient satisfaction was evaluated from the chart at the

most recent follow-up, using an acquired-informal questionnaire to grade the patient's level of satisfaction with the aesthetic results (see the Appendix, available online at www.aestheticsurgeryjournal.com). The satisfaction questionnaire was anonymous, in a paper format, and was distributed by the clinic secretaries during the postoperative follow-up visit. The patients classified their level of satisfaction as very satisfied, satisfied, disappointed, or regretting their decision. Postoperative photographs were obtained at follow-up appointments and compared with the preoperative images.

Preoperative Markings/Implant Selection

Before surgery, marks are drawn on the skin corresponding to the current inframammary fold (CIMF), the lateral limit of the pocket represented by the anterior axillary line (AAL), and the midsternal line (MSL). The parasternal lines (PSLs) are generally marked, maintaining 2 to 3 cm between the breasts. The superior and inferior limits of the pocket, represented by the future IMF (FIMF) and superior breast line (SBL), are planned according to the implant volume, which permits accurate centering of the implant and maintains precise pocket dimensions based on the implant size (Figures 1 and 2). Implant volume is selected together with the patient, considering factors such as height, weight, and thoracic cage. A temporary area between the upper limit of the planned pocket and the clavicle area is marked as the region for subsequent AFG; this area usually represents the cleavage limits and the transition between the implant and nonimplant zones that should be grafted to achieve a homogeneous transition. Breast and thoracic asymmetries are identified, and corrected as much as possible with AFG or different implants, if necessary.

AFG

In all patients in this cohort, high-profile (full-projection) implants were placed in the SF plane. After the implant was inserted into the pocket, with the patient seated at a 90° angle the medial-superior, lateral-superior, and superior limits of the implant are marked according to the presurgical markings as well as intraoperative analysis. To do so, both implants are pushed upward to simulate the cleavage limits. Fat is usually harvested from the abdomen or the inner/outer thighs using a 3.0-mm cannula with beveled 1.5-mm ports (Faga Medical, Bauru, Brazil) connected to a 60-mL Luer-Lok syringe (BD Medical, Curitiba, Brazil). The AFG is washed and filtrated using lactated Ringer solution through the closed system (PureGraft, Solana Beach, CA) and transferred to 3-mL syringes (BD Medical, Curitiba, Brazil) for injection. Based on the Coleman principles,^{34,35} the AFG is injected via a 15-cm cannula with diameters of 1.9 to 2.1 mm (Faga Medical, Bauru, Brazil), with retrograde strings. The AFG is then spread superficially in the subcutaneous tissue from the upper pole toward the

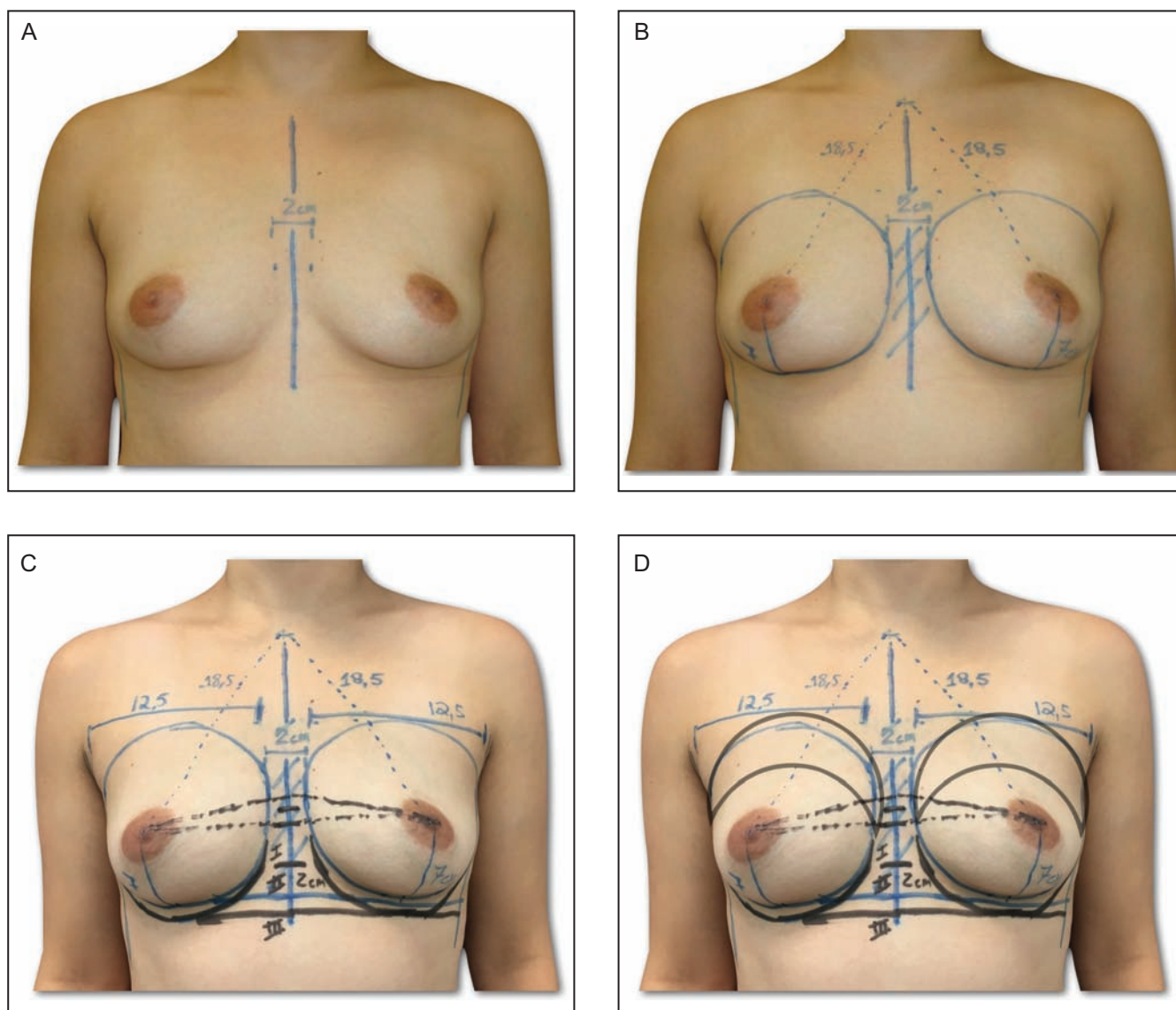


Figure 1. (A-D) Preoperative markings on a 32-year-old female patient presenting with postpartum bilateral symmetrical hypomastia, desiring restoration of volume, natural transition on the upper pole, and projection. The skin markings include current inframammary fold, lateral limit of the pocket represented by the anterior axillary line, midsternal line, and parasternal lines, with 2 cm between the breasts. The markings for the autogenous fat grafting area are made temporarily in the cleavage limits, which represent the future transition between the implant zone and the nonimplant zone.

lateral and medial upper quadrants to simulate a homogeneous transition between the implant and nonimplant areas (Figures 3 and 4). If necessary, a second puncture is made to crisscross the injections. Layered wound closure is performed without the use of suction drains; an elastic band is placed over the upper breast poles in patients subjected to a transaxillary approach. All patients receive intravenous antibiotics, and oral antibiotics are continued for 48 hours. The band is maintained for 4 weeks; early massaging/mobilization of the breasts is avoided for at least 2 to 3 months and physical activities avoided for a period of 6 to 8 weeks.

Mathematical Equation

In order to obtain ideal shape and outcome in HBA by transforming a round implant into a composite anatomic breast, several measurements are taken, in a series of steps, according to a 3-dimensional (3D) geometric breast model (Figure 5A). The SketchUp software system (Trimble Inc, Sunnyvale, CA) was used to calculate and design 3D models representing the area of the implant and the AFG in the upper pole. The first step was to locate the farthest-projecting point of the round geometric figure, which corresponds to the tip of implant projection. The

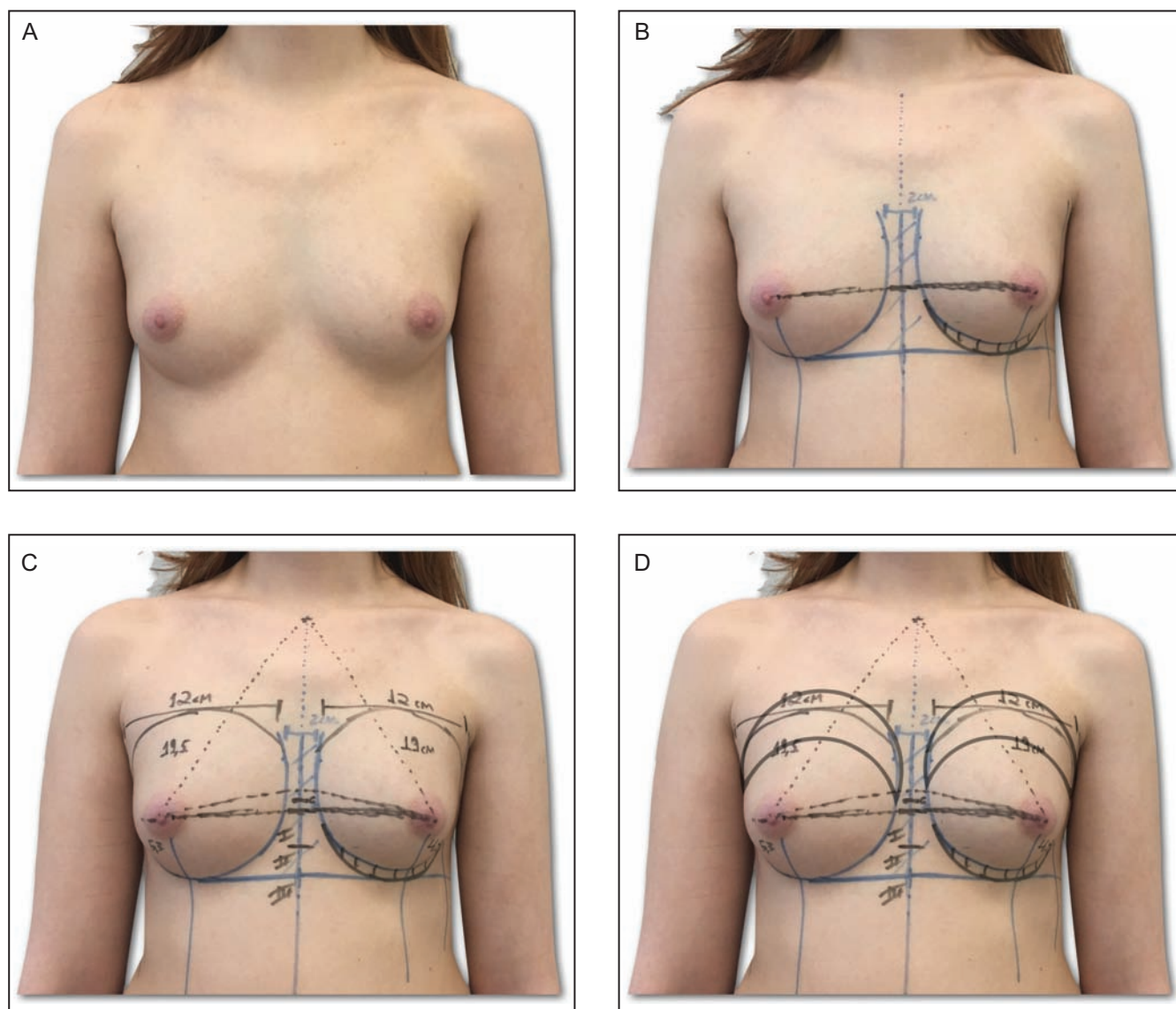


Figure 2. (A-D) Preoperative markings on a 22-year-old, female patient presenting with bilateral asymmetrical hypomastia and different inframammary fold position, desiring restoration of breast symmetry, upper pole fullness, and projection. Similar markings were made including the current inframammary folds (right and left), lateral limit of the pocket represented by the anterior axillary line, midsternal line, and parasternal lines (PSL), with 2 cm between the breasts. The markings for the autogenous fat grafting area are made temporarily in the cleavage limits, which represent the future transition between the implant zone and the nonimplant zone in order to achieve a homogeneous transition.

midpoint at the base of the implant (below the farthest-projecting point) corresponds to the radius or half of the base diameter. A line was then drawn from the top of the implant at a 60° angle until it reached the tangent to the implant base; this creates a cone shape, which was connected to the area to be grafted at the superior breast pole (Figure 5D). These basic lines yielded the mathematical formula for calculating the ideal volume to fill the area, $V_{AFG} = (\pi \cdot r^2 \cdot p)/6$, where r represents radius and p represents projection. However, because we are aware

of the approximate expected volume of AFG absorption (approximately 25%, acquired from the literature as well as personal experience), a correction was made to produce the final formula, $V_{AFG} = (\pi \cdot r^2 \cdot p)/4.8$ (Figure 5D). This final formula was then used to calculate AFG volume for 3 projections available for Motiva SmoothSilk/SilkSurface implants (Motiva/Establishment Labs, Coyal Free Zone, Alajuela, Costa Rica), namely moderate (demi), high (full), and extra-high (coarse) projections, and present the results based on different volumes.

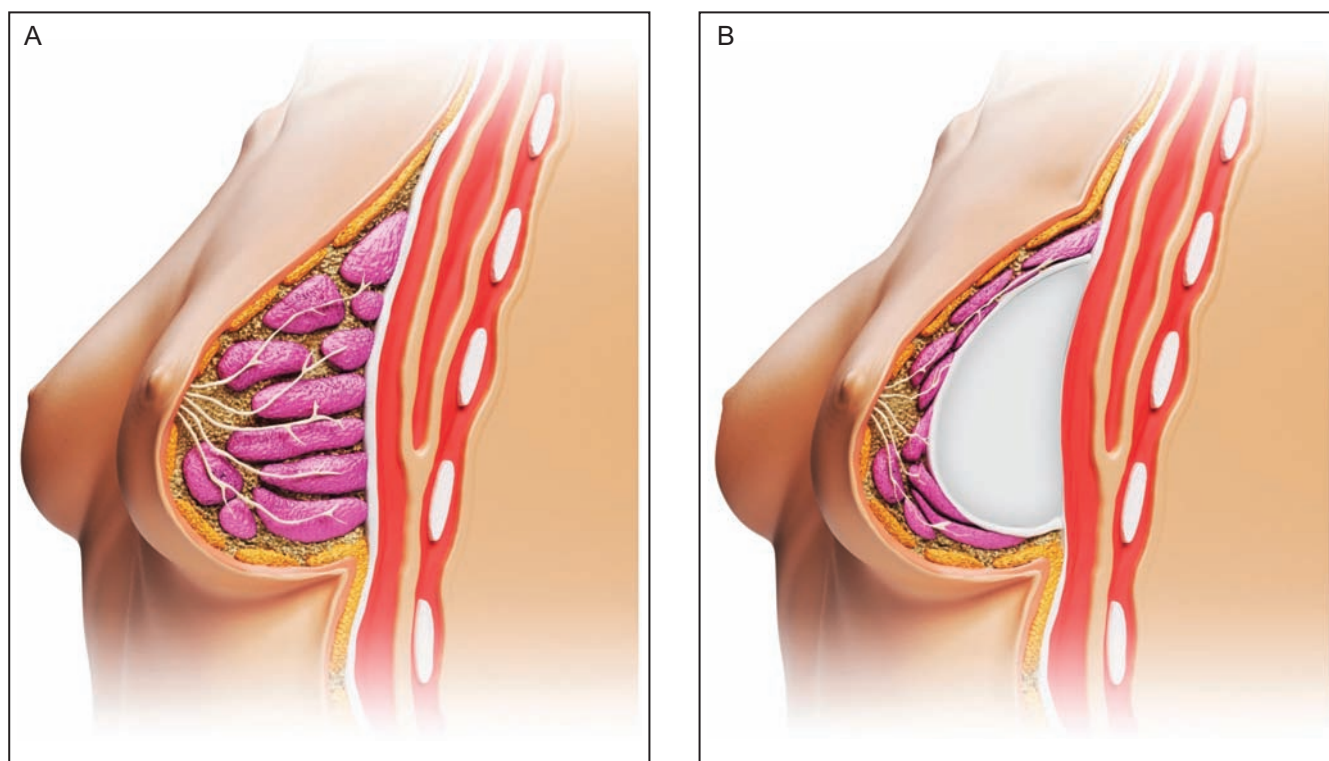


Figure 3. Schematic illustrations of subfascial breast augmentation. (A) Preoperative breast and pectoral fascia anatomy showing the breast and soft tissue with a poor coverage, pectoralis fascia, and pectoralis major muscle. Subfascial breast augmentation. The anterior wall of the implant pocket consists of pectoralis fascia, breast parenchyma, subcutaneous tissue, and skin. (B) Due to insufficient coverage, an abrupt transition between the area with the implant and the upper pole without the implant is noted in the scheme.

Statistical Analysis

To test the applicability of this formula in accurately predicting ideal AFG volumes, we compared our formula with the results in a cohort of 30 consecutive patients (60 breasts) who underwent hybrid BA performed by an experienced surgeon (A.M.M.). Continuous variables were tested for normality with the Shapiro-Wilk test. Variables with normal distribution were presented as mean and standard deviation; nonparametric variables were presented as median and interquartile range. Categorical variables were presented as absolute numbers and percentages. The Pearson test was used to analyze the correlation between AFG performed in the cohort and the values predicted by the new formula. SPSS version 2.0 software (SPSS Inc, Chicago, IL) was used to perform the analysis. Similar graphs and correlation coefficients based on implant volume and projection were generated by comparing actual AFG with the estimates derived from the new formula. The significance level was accepted as $P < 0.05$ at a 95% confidence interval.

RESULTS

The authors performed this technique in 30 patients (60 breasts) undergoing primary HBA. The implants ranged

from 175 to 355 cc, (mean, 265 cc), and were all Ergonomix-style Motiva SmoothSilk/SilkSurface implants. The demographic data and mean anthropomorphic measurements are presented in Table 1; average age, BMI, and pinch test were 33 years (range, 22-48 years), 21.1 kg/m² (range, 18-27 kg/m²), and 1.6 cm (range, 1.0-2.3 cm), respectively. The mean volumes of AFG harvested and grafted were 265 mL (range, 175-380 mL) and 79.2 mL per breast (range, 50-110 mL), respectively. AFG was harvested from the abdomen and thighs (inner and outer) in 75% of cases, followed by the hips (20%) and knees (5%). Mean operating time was 160 minutes (range, 80-250 minutes).

Outcome/Complications

Three cases of complications were observed in 2 patients (10%): subcutaneous banding in the axilla ($n = 2$, 6.6%), minor wound dehiscence and hypertrophic scarring at the axillary incision ($n = 1$, 3.3%). One patient presented a minor unilateral dehiscence that healed with periodic dressings and evolved to a localized unilateral hypertrophic scar. After 1 year of follow-up, the patient was satisfied with the result and did not want scar revision surgery. The other patient presented subcutaneous banding in the axillary region of the upper inner arm. The patient was instructed

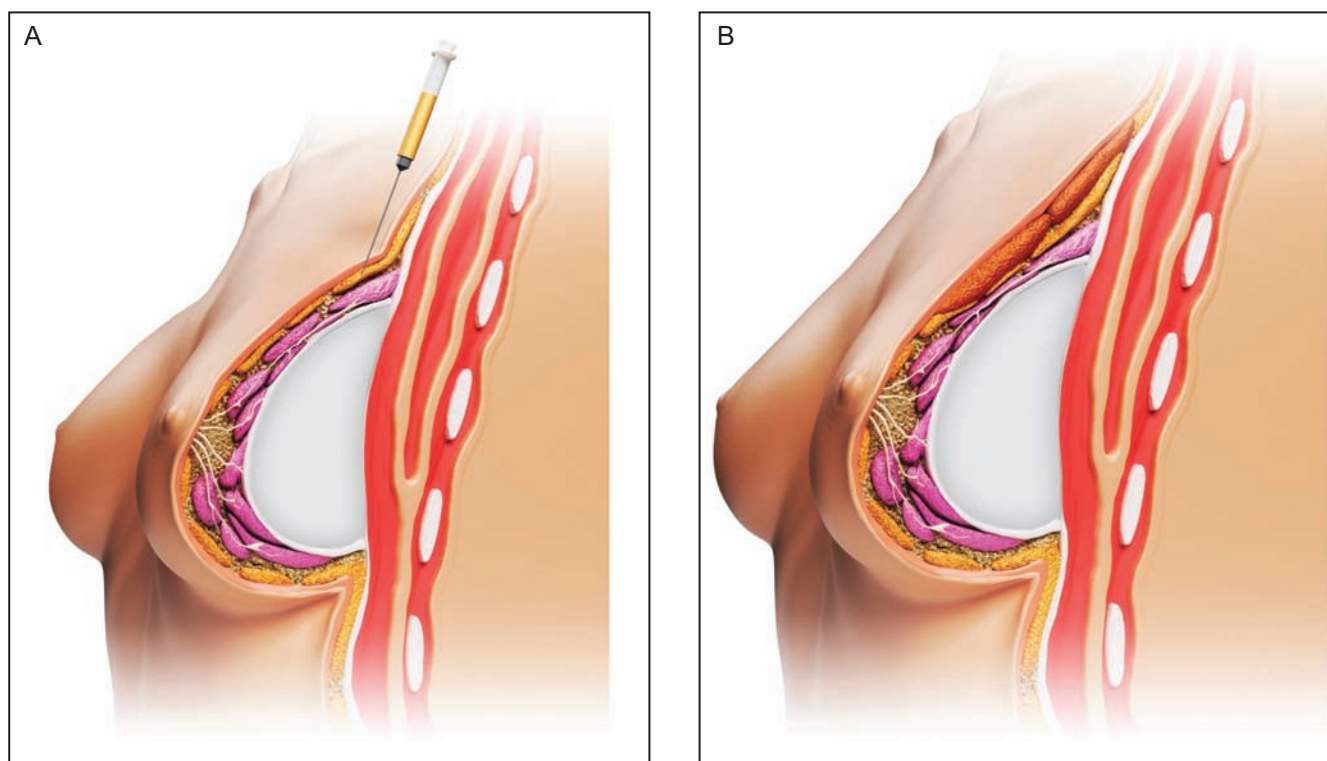


Figure 4. Schematic illustrations of hybrid breast augmentation. (A) Breast and pectoral fascia anatomy following subfascial breast augmentation associated with autologous fat grafting. (B) Final result showing a natural transition between the silicone implant and the upper breast pole due to autologous fat grafting.

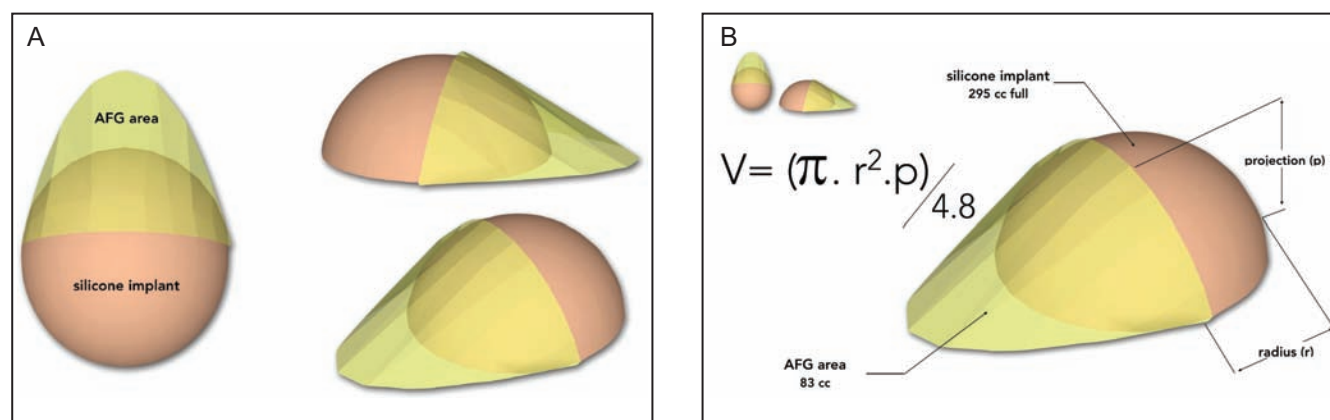


Figure 5. (A) Reconstructed 3D model of the breast created with the SketchUp system (Trimble Inc., Sunnyvale, CA, US), showing the ideal shape for a hybrid breast augmentation. The simulated AFG area is achieved by transforming a round implant into a shaped format with AFG in a cone-type shape on the upper part of the implant. (B) Reconstructed 3D model of the breast created with the SketchUp system and the mathematical formula devised to calculate the volume required for AFG grafting (r = radius, p = projection). AFG, autogenous fat grafting.

to massage the area after the second week; the outcome was satisfactory, with complete resolution of symptoms. No cases of infection, rotation, hematoma, seroma, or fat necrosis were observed during a mean follow-up of 18 months (range, 6-28 months). Patient satisfaction was evaluated at least 6 months after the procedure

(6-8 months); 29 patients (96.6%) were either very satisfied or satisfied with their aesthetic results, 1 patient (3.3%) was partially disappointed and thought the implants were small, and no patients regretted the surgery (Figure 6 and Supplemental Figures 1 and 2, available online at www.aestheticsurgeryjournal.com).

Table 1. Hybrid Breast Augmentation: Patient Demographic Data

| Characteristic | Value (%) |
|---|-----------|
| No. of patients | 30 |
| Age, years | |
| Median | 33.3 |
| Range | 22-48 |
| BMI | |
| Median | 24.1 |
| Range | 18-28 |
| Breast measurements, cm | |
| Sternal notch-to-nipple distance (SN-N) | |
| Median | 18.5 |
| Range | 18-21 |
| Nipple to IMF (N-IMF) | |
| Median | 6.5 |
| Range | 5.2-7.8 |
| Intermammary distance (IM) | |
| Median | 4 |
| Range | 2.1-4.8 |
| Incision | |
| Axillary | 25 (83.3) |
| IMF | 5 (16.6) |
| Periareolar | 0 (0.0) |
| Volume of implants | |
| Median | 278.17 |
| Range | 175-335 |
| Implant base diameter, cm | |
| Median | 10.53 |
| Range | 9-11.25 |
| Implant projection, cm | |
| Median | 4.31 |
| Range | 3.7-4.6 |
| AFG harvest volume | |
| Median | 265 |
| Range | 175-380 |

Table 1. Continued

| Characteristic | Value (%) |
|---------------------------------|-----------|
| AFG grafted volume (per breast) | |
| Median | 79.23 |
| Range | 50-110 |

AFG, autogenous fat grafting; BMI, body mass index; IMF, inframammary fold.

Mathematical Equation and Clinical Correlation

The calculated AFG volumes were compared with the implant volumes and projections, and the data are summarized in [Figures 7 and 8](#) and [Tables 2-4](#). The experimental formula was compared with the results from the patient cohort, and the results are summarized in [Figure 9](#). The clinical results showed a direct linear relation between high-profile (full-projection) implant and the predicted values for AFG ([Figure 9](#)). This linear behavior was similar in the mathematical formula for the extra-high-profile implant, but the curve was steeper because of its smaller radius. The Pearson correlation between AFG performed in the cohort and the values predicted by the formula was very high ($r = 0.938$, $P < 0.001$), indicating that the volumes used in the clinical cohort were similar and highly correlated to the calculated AFG volumes. Note that the cases are uniformly distributed around the calculated line with only 1 exception ([Figure 9](#)).

DISCUSSION

The SF approach to BA was first introduced to clinical practice in the 1990s and has been described thoroughly by several authors who report satisfactory outcomes.⁸⁻²² Advantages of this procedure include lower morbidity due to a more superficial plane of dissection and the ability to provide more soft tissue coverage for the implant than the subglandular BA technique.^{9,10,14-16,21,22}

Over the past 10 years, SF BA has undergone a number of modifications to improve reliability and clinical outcomes.^{9,10,14-16,21-28} One specific limitation of the SF procedure, and a reason why technical alternatives were required, is related to very thin patients with insufficient tissue coverage.²¹ When breast tissue measures less than 2 cm (real tissue coverage of 0.5-1.0 cm), pectoralis fascia coverage is limited, and a SM position is recommended. In these cases, SF HBA can offer an alternative for camouflaging the implant similar to the SM technique.^{21,23-28}

As for aesthetic results following SF BA, a conspicuous upper implant edge represents an undesired outcome,

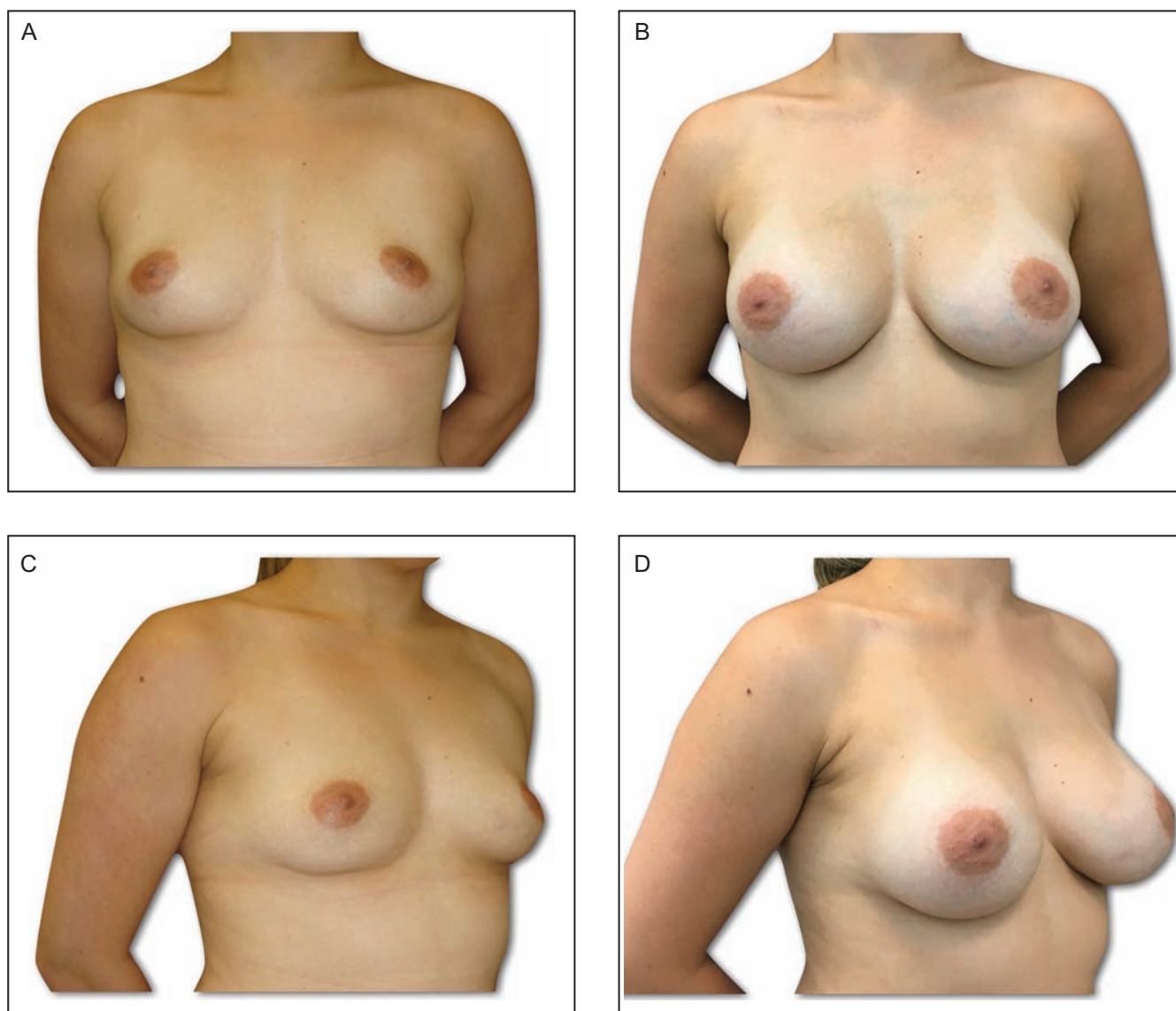


Figure 6. Preoperative (A) frontal, (C) left oblique, and (E) lateral views of a 32-year-old female patient, previously presented in Figure 1, with postpartum bilateral symmetrical hypomastia, desiring restoration of volume, natural transition on the upper pole, and projection. (B, D, F) Postoperative views showing a very good outcome 2 years after bilateral augmentation with 245-cc SmoothSilk surface silicone implants associated with 82 mL of autogenous fat grafting in each breast.

especially in patients with very little glandular and subcutaneous tissue in the upper pole areas.^{14,16,21,22} In these patients, the upper lateral and medial borders of the breast may be apparent, unlike the shape of a “natural” breast. In these cases, HBA can improve the transition zone between the pectoralis muscle, the sternum, and the implant (Figures 3 and 4).^{21,23-28} By identifying these patients prior to the procedure and recommending AFG in “risky” areas, outcomes may be improved, consequently reducing the need for revision surgeries that could potentially lead to patient dissatisfaction. In our series, based on primary²¹ and secondary^{21,34} hybrid BA procedures, we used a pinch test result of <2 cm as the main indication for AFG.

In recent years, AFG has been widely indicated as an adjunct tool in breast surgery to restore volume and contour defects with technical variations on fat harvesting, preparation, and grafting.³¹⁻³³ As a result, HBA in patients with low coverage has become attractive and more frequent.^{21,23-28} Recent refinement of the AFG technique has permitted reductions in the incidence of local complications secondary to reabsorption, lumps, and fat necrosis.^{21,23-36} Coleman introduced the concept of structural AFG introduced via small cannulas for soft tissue rejuvenation, with satisfactory results.^{35,36} Khouri et al³⁷ advocated small fat droplets associated with preparing the recipient site via external expansion. Carpaneda et al³⁸ correlated volume and percentage of AFG viability; these



Figure 6. Continued.

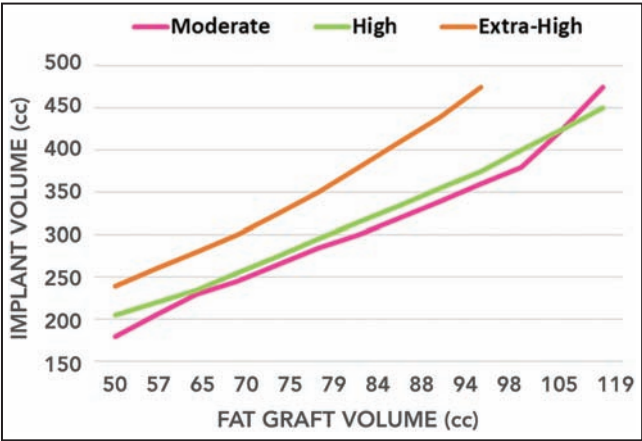


Figure 7. Linear graph of values for implant volumes (cc) vs autogenous fat grafting volume according to silicone implant projection (moderate, high, and extra-high projection).

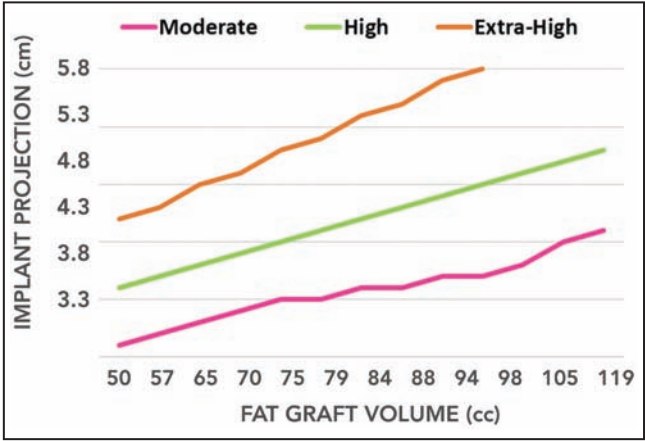


Figure 8. Linear graph of values for implant projection (cm) vs autogenous fat grafting volume according to silicone implant projection (moderate, high, and extra-high projection).

authors found that the percentage of AFG survival depends on graft volume and is inversely proportional to the graft diameter and volume grafted. These findings corroborate the notion that the HBA technique may be limited by the volume of AFG that can be grafted because there is an inverse relationship between the AFG volume and fat integration..^{37,38}

We have perceived that in order to estimate the AFG volume in an HBA procedure, most plastic surgeons appear

to rely on their own experience and intuition based on similar cases they have treated. In some cases volume is overestimated, resulting in unnecessary procedures and wasted fat. In other cases the volume is underestimated, requiring additional AFG harvesting and additional surgical time. Furthermore, inaccurate predictions of AFG volume could result in incorrect assessment of donor areas, and even hamper future surgeries if additional grafts are needed.

Table 2. Moderate-Profile SmoothSilk Implant Features (Base and Projection) and the Volume of Autogenous Fat Grafting Based on the Mathematical Equation

| Implant volume, cc | Base, cm | Projection, cm | AFG volume, mL |
|--------------------|----------|----------------|----------------|
| 205 | 10 | 3.5 | 57.27 |
| 230 | 10.5 | 3.6 | 64.94 |
| 245 | 10.75 | 3.7 | 69.96 |
| 265 | 11 | 3.8 | 75.23 |
| 285 | 11.25 | 3.8 | 78.69 |
| 300 | 11.5 | 3.9 | 84.39 |
| 320 | 11.75 | 3.9 | 88.10 |
| 340 | 12 | 4 | 94.25 |
| 360 | 12.25 | 4 | 98.22 |
| 380 | 12.5 | 4.1 | 104.82 |
| 425 | 13 | 4.3 | 118.91 |
| 475 | 13.5 | 4.4 | 131.21 |

AFG, autogenous fat grafting.

Table 3. High-Profile SmoothSilk Implants Features (Base and Projection) and the Volume of Autogenous Fat Grafting Based on the Mathematical Equation

| Implant volume, cc | Base, cm | Projection, cm | AFG volume, mL |
|--------------------|----------|----------------|----------------|
| 220 | 9.75 | 4 | 62.22 |
| 235 | 10 | 4.1 | 67.09 |
| 255 | 10.25 | 4.2 | 72.20 |
| 275 | 10.5 | 4.3 | 77.57 |
| 295 | 10.75 | 4.4 | 83.20 |
| 315 | 11 | 4.5 | 89.09 |
| 335 | 11.25 | 4.6 | 95.26 |
| 355 | 11.5 | 4.7 | 101.71 |
| 375 | 11.75 | 4.8 | 108.43 |
| 400 | 12 | 4.9 | 115.45 |
| 425 | 12.25 | 5 | 122.77 |
| 450 | 12.5 | 5.1 | 130.39 |

AFG, autogenous fat grafting.

Table 4. Extra-High-Profile SmoothSilk Implants Features (Base and Projection) and the Volume of Autogenous Fat Grafting Based on the Mathematical Equation

| Implant volume, cc | Base, cm | Projection, cm | AFG volume, mL |
|--------------------|----------|----------------|----------------|
| 260 | 9.75 | 4.6 | 71.55 |
| 280 | 10 | 4.8 | 78.54 |
| 300 | 10.25 | 4.9 | 84.24 |
| 325 | 10.5 | 5.1 | 92.00 |
| 350 | 10.75 | 5.2 | 98.33 |
| 380 | 11 | 5.4 | 106.91 |
| 410 | 11.25 | 5.5 | 113.90 |
| 440 | 11.5 | 5.7 | 123.34 |
| 475 | 11.75 | 5.8 | 131.02 |

AFG, autogenous fat grafting.

Although AFG volume evaluation is essential to HBA procedures, it has not been fully understood by many plastic surgeons. The lack of a simple, inexpensive, and standardized method may be one reason why this evaluation is not routinely done. As a result, a mathematical equation, which

can provide guidelines for estimating the volume of AFG required, could enhance surgical planning in HBA.

To date, no previous studies have evaluated methods for predicting the volume of fat to be grafted. Earlier studies described methods for estimating breast tissue volume, such as water displacement,^{39,40} anthropomorphic measurements,^{41,42} or magnetic resonance imaging (MRI).⁴³ However, limitations include costs, time involved, or widely variable results. Although several studies have addressed AFG preparation and grafting techniques,³¹⁻³³ an equation for calculating the volume of fat needed to supplement implant volume has yet to be described.

Recent decades have seen major advances in engineering and medical systems for acquiring external surface images or 3D anatomic views of internal structures, with applications in various disciplines of medicine.⁴⁴⁻⁴⁸ Evolution in 3D imaging techniques, and especially 3D stereophotogrammetry, has also contributed to better estimates of volume during breast surgery planning.⁴⁴ Mathematical principles can be used to calculate the volume of any shape, and consequently how much additional volume would be needed to entirely fill such a shape with fat grafts. Bangeas et al⁴⁹ used images of abdominal aortic aneurysms created with computed tomographic angiography and converted into 3D images by Google SketchUp. A 3D printer then created a 3D model of an abdominal aorta aneurysm; these authors describe

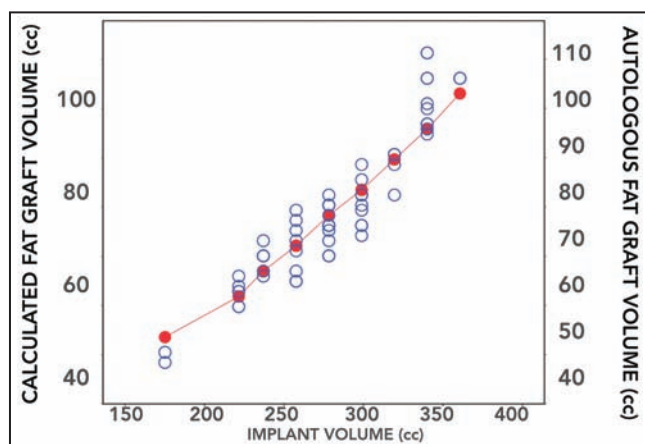


Figure 9. Scatterplot of implant volume (cc) vs the volume of fat grafted and calculated by the formula. The correlation between the AFG performed in the cohort and the values predicted by the formula found by the Pearson test were high ($R = 0.945$), indicating that the volumes used in the clinical cohort were similar and highly correlated to the calculated AFG volumes. AFG, autogenous fat grafting.

the use of such models for more biocompatible and individualized surgical treatment. Govsa et al⁴⁵ also recreated arterial anomalies from 3D printed anatomic models. These authors used computed tomographic angiography images of coiling in the internal carotid artery, which they then converted into 3D images with SketchUp. These arterial models were then used to assess geometric features, degree of curve, and extension, which were then used to simulate patient-specific procedures.

In our study we utilized the SketchUp system, which is based on 3D computer modeling and commonly used in nonmedical areas such as architecture, mechanical engineering, and video game design.⁵⁰ The program is available as a web-based application, in free and paid versions (SketchUp Free and SketchUp Pro, respectively), and includes drawing layout functionality which permits surface rendering in various styles. In order to create 3D models (and following other authors who used the same technology to solve problems in surgical areas^{45,46,49}) we adapted the same concepts to resolve our questions about volumetric calculations of AFG (Figure 5A, D).

This study introduces a method based on a mathematical equation, which utilizes implant base/projection to predict the amount of AFG necessary to achieve a homogeneous transition between regions with and without an implant. This mathematical analysis was compared to a retrospective evaluation of 60 consecutive breasts submitted to HBA procedures performed by a single surgeon (A.M.M.), and a high correlation was established between the values obtained from the formula and the AFG volume which was actually grafted. The results of this study

confirmed our initial hypothesis that a mathematical formula could predict the AFG volume required according to the dimensions/projection of the implant. This formula was further refined by avoiding other variables in our comparison of results (such as data from a single surgeon using only one HBA technique, thus avoiding variations resulting from different surgeons and techniques).

The degree of association between the AFG volume determined by the equation and the AFG volume in the HBA was measured with Pearson's correlation coefficient.⁵¹ This coefficient measured linear association represented in a scatter plot, where every positive increase in one AFG variable represented a positive increase in a fixed proportion of real fat graft volume (Figure 9). Correlation is generally used in statistics to describe an association between 2 continuous quantitative variables, and the Pearson's coefficient (r) measures the strength of the association between the 2 variables.^{51,52} In our sample, we observed a direct correlation between the expected and the real AFG variables ($r = 0.938$, $P < 0.001$), indicating a direct relation between implant volume and the AFG volume needed in the upper pole of the breast to simulate a conical and homogeneous shape. Similarly, increased implant projection (high and extra-high style) led to greater fat volumes; an extra-high-projection implant requires approximately 30% more AFG volume than a moderate-projection implant of similar volume to produce a uniform shape.

In our experience, the ideal shape for a hybrid BA procedure was obtained by transforming a round implant by adding AFG in a pattern similar to a cone shape on the upper portion of the implant. This geometric figure led us to the mathematical formula that allows us to calculate the accurate AFG volume required for each of the 3 different implant projection styles. Approximately 25% is added to the final volume to be grafted in order to compensate for any resorption. In analyzing our formula, we can conclude that the radius has the greatest impact on predicted AFG volumes in comparison with projection. The different implant projections only slightly affect the curves (Figure 8). Moderate profile implants, which have a proportionally larger base diameter and radius, were expected to involve larger AFG volumes. But the volume for these implants shows only a very small increase in diameter base compared with the previous volumes, leading to a curve with behavior resembling the extra-high-profile implants.

Recently, silicone implants have advanced with the introduction of new surfaces and viscoelastic gel properties.⁵³⁻⁵⁶ With progress in gel technology, the Ergonomix-style Motiva SmoothSilk/SilkSurface implants are the first generation of breast implants with very low roughness in order to avoid tissue ingrowth and minimize bacteria adhesion.⁵³⁻⁵⁶ Besides the surface topography, these implants also incorporate enhanced rheologic properties, simulating

the natural dynamics of breast tissue.⁵⁵ Ergonomix implants are filled with ProgressiveGel Ultima, a highly elastic gel with low viscosity and superior adaptability capabilities that provides a more natural appearance.^{54,55} We utilized these implants in our sample with volumes ranging from 175-355 cc (mean, 265 cc).

In 2018, a prospective US Food and Drug Administration (FDA) trial was started to evaluate the safety and effectiveness of Motiva SmoothSilk/SilkSurface implants in American women undergoing primary breast augmentation, reconstruction and revision surgeries.⁵⁷ The present FDA core study is a multicenter, single-arm effort involving 750 patients in 4 cohorts and an MRI subpopulation of 250 patients to evaluate rupture rates. Similar to previous FDA premarket clinical trials of silicone implants, results are expected after a 3-year follow-up, along with possible approval of these implants for the US market.

In spite of the physical benefits, the literature on Ergonomix implants is limited and mostly based on the expertise of a few authors and retrospective series.⁵³⁻⁵⁶ At the time of this writing, we do not have more accurate data about the time needed for the implant to reach its final position due to its elastic properties. In our opinion, it is complex to predict the average time an implant requires to descend and settle from its initial implanted position. In our sample, all patients were young (average age, 33 years), with very good skin quality, and medium-volume implants were used (average, 265 cc). In our clinical experience and in this specific group of patients, the vast majority of implants reached their final position within 4 to 6 months. We consequently established a minimum of 6 months to evaluate results and patient satisfaction in this series. However, in groups of patients with different characteristics (older, poor-quality skin, larger implants), a longer follow-up period may be necessary for more accurate assessment.

In our clinical series, patients underwent surgery between June 2017 and April 2019, all by the same surgeon and using the same technique for breast augmentation and AFG. All data related to the surgical procedure were collected and retrospectively analyzed. The patients were followed and analyzed at specific periods, including less than 10 days, 1, 3, 6, and 12 months, and then at 2-year intervals postprocedure, depending on the time of surgery. Outcome and satisfaction were analyzed for at least 6 months to assess proper AFG integration and complete resolution of surgery-related swelling and edema. At the time of this writing, almost 97% of the patients were either very satisfied or satisfied with their results, and none regretted the surgery. A satisfactory aesthetic result was obtained, maintaining a natural breast shape and smooth transition between the upper pole and implant area. Even with these satisfactory results, the patients continue to be followed in order to evaluate long-term outcomes. Our

current average follow-up is 18 months, and good results and satisfactory integration of AFG in the upper pole region of the breast were observed in all patients. We also point out that the grafted volume was not large (79.2 mL per breast; range, 50-110 mL), and that medium-volume implants were used (mean, 265 cc; range, 175-355 cc), which in association with good grafting technique encourages AFG integration.

Despite the aesthetic advantages, procedures combining AFG and silicone breast implants present some drawbacks. These include the need for previous training and surgical skills as well as additional costs, and longer operative time has also been mentioned as a relative disadvantage. Although these factors may be important, with experience the additional operative time should decrease. In our study, the mean operating time was 160 minutes (range, 80-250 minutes). In our sample, we had 2 patients who underwent conventional liposuction in order to improve body contouring (including the back, thighs, and abdomen), which resulted in increased operative time. In the remaining 28 patients, liposuction was limited and exclusively for collecting fat for the hybrid surgery, which resulted in an approximate surgical time of 120 minutes.

Most complications in our sample were minor and occurred during the initial postoperative period: subcutaneous banding in the axilla, minor wound dehiscence, and hypertrophic scarring. No cases of infection, rotation, hematoma, seroma, or fat necrosis were observed during a mean follow-up of 18 months (range, 6-28 months). In a single case in our sample, the volume of AFG obtained using our formula differed from the AFG volume actually grafted during surgery. In this specific case, the patient underwent secondary BA surgery and presented superior breast pole asymmetry, which required a greater AFG volume to correct the aesthetic alteration. In this single case (considered an outlier), 110 mL of AFG was actually grafted, whereas the formula predicted a volume of 95 mL. Additional studies are consequently required to evaluate the reproducibility of the formula in special cases of HBA, and should address specific patient groups, such as larger asymmetries.

One strength of our study is that the surgical procedures were performed by a single surgeon in a consecutive-case design that followed the same preoperative planning and utilized the same surgical technique. Second, a specific, objective, and well-established tool with previous applications in other medical and nonmedical areas was used for volumetric calculation of different geometric figures. Comparison of these volumetric data with clinical experience showed a high statistical correlation. Despite these aspects, our study has some limitations. First, the clinical series was observational and nonrandomized, and may consequently have been prone to selection bias. We

continue to collect prospective data on this topic in order to augment our sample and report future outcomes related to other patient subgroups. Second, although there are various ways to classify “successful” surgical outcomes, the focus of this study was the correlation between projected AFG volume and actual data. Additional studies should consequently focus on aesthetic results, AFG intake, and long-term satisfaction surveys based on validated patient questionnaires to further contribute to our data. Third, our clinical series was restricted to only 1 type and style of Motiva SmoothSilk/SilkSurface implants (Ergonomix, high projection), and the formula was applied to implants with volumes ranging from 175 to 450 cc. As a result, further investigation is necessary to evaluate whether the results extend to implants beyond the groups analyzed in the present study. Furthermore, the equation might not be acceptable for breasts with ptosis if an augmentation-mastopexy technique is necessary. Additional studies are consequently necessary to validate our formula for other surgical procedures, and for implant styles such as saline-filled, nondynamic gel implants and Ergonomix with moderate/extra projection styles.

Advances in AFG procedures and new-generation silicone gel implants have led to significant progress in esthetic outcomes following BA. In our experience, AFG is most frequently associated with HBA in the upper, medial, and lateral breast areas, where thin tissue provides insufficient coverage and leads to implant visibility. The present technique can play a valuable role in BA, and the results of our experience show it to be a simple and predictable procedure, providing optimal aesthetic outcomes with natural shape, and adequate size and projection.

CONCLUSIONS

The AFG volume required for grafting in hybrid BA can be reliably calculated utilizing simple measurements based on implant volume and projection. This low-cost method for assessing AFG volume via a mathematical equation can be used to guide surgical decision-making in treating thin patients with hypomastia who are candidates for HBA. Our experience thus far shows that this equation permits the surgeon to perform hybrid BA with SmoothSilk implants in a simple, reproducible, and more precise manner.

Supplementary Data

This article contains supplementary material located online at www.aestheticsurgeryjournal.com.

Disclosures

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