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ORIGINAL ARTICLE

BREAST SURGERY

Three-dimensional Evaluation of Results After Dual-Plane Breast Augmentation with and Without Internal Suture Mastopexy

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Abstract

Background In patients with breast atrophy and ptosis, it is necessary to correct both problems simultaneously. This study aimed to analyze breast morphological changes with a three-dimensional (3D) scanning technique to demonstrate the improvement effect of dual-plane breast augmentation combined with internal suture mastopexy.

Methods 3D breast surface scans were performed preoperatively and postoperatively in 24 patients ($n = 35$ breasts) undergoing internal suture mastopexy combined with prosthetic augmentation through the periareolar approach and 24 patients (48 breasts) undergoing simple dual-plane breast augmentation. Changes in linear distance, breast volume and volume distribution, breast projection, and nipple position were analyzed to assess the breast morphology.

Results Compared with simple breast augmentation, augmentation combined with internal suture mastopexy was associated with a higher upper pole volume increase and greater medial and upward nipple displacement. After the surgery, the upper pole volume increased by an average of 10.6% in combined augmentation group and decreased by an average of 2.2% in the simple breast augmentation group. The measured breast projections were 24.8 ± 2.2% lower than expected in the combined group and 23.1 ± 4.1% lower than expected in the simple group, based on implant parameters recorded by the manufacturer. The nipple moved 0.2 ± 0.5 cm laterally, 1.6 ± 0.6 cm upward, and 2.8 ± 0.7 cm anteriorly in the combined group and 0.9 ± 0.5 cm laterally, 0.7 ± 0.6 cm upward, and 3.0 ± 0.6 cm anteriorly in the simple group.

Conclusions Dual-plane breast augmentation in addition to internal suture mastopexy appears to reposition breast tissue from the lower pole to fill in the deficient upper breast, pull the nipple medially and superiorly, and ultimately correct mild to moderate breast ptosis.

Level of Evidence III This journal requires that authors assign a level of evidence to each article. For a full description of these Evidence-Based Medicine ratings, please refer to the Table of Contents or the online Instructions to Authors www.springer.com/00266.

Keywords Breast augmentation · Internal suture mastopexy · 3D measurement

Introduction

Breasts represent femininity, and breasts with a natural, plump, young, and beautiful appearance are desired by many women. Currently, a growing number of women suffer from breast volume loss as well as mild or mild to moderate ptosis. For these patients, prosthetic augmentation combined with mastopexy, performed simultaneously or in stages, has traditionally been applied. However, the safety of these procedures and resulting patient satisfaction are controversial due to the high rate of various

Xin-Rui Li, Li Zeng and Wei-Jin Hong have contributed equally to the work and were considered to be co-first authors.

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postoperative complications and the high incidence of secondary surgical repair.

Recently, a technique for internal suture mastopexy combined with prosthetic augmentation has been proposed to correct mild to moderate breast ptosis [1]. This method has been reported to yield good results in correcting breast ptosis, with low complication rates and less extensive mastopexy incisions. However, there is a lack of objective breast measurement data to support the improvement effect. Three-dimensional (3D) scanning is a highly precise and useful technique for the preoperative and postoperative evaluation of breast morphology [2–4]. The goal of this study was to analyze breast morphological changes after internal suture mastopexy combined with prosthetic augmentation for mild to moderate breast ptosis with a 3D scanning technique.

Materials and Methods

Patient Enrollment

This is a retrospective study. The retrospective data collection was submitted by the first author. The study was approved by the Ethics Committee of our hospital before being conducted. We obtained written informed consent in accordance with research ethics committee guidelines. Combined augmentation group inclusion criteria : (1) Patients with mild to moderate breast ptosis undergoing primary internal suture mastopexy combined with prosthetic augmentation or simple primary dual-plane breast augmentation; (2) Undergoing a long-term follow-up (more than 1 year); and (3) with available 3D scanning data. Patients with severe breast ptosis were excluded. Simple augmentation group inclusion criteria: (1) Patients with insufficient breast volume undergoing simple primary dual-plane breast augmentation; (2) Undergoing a long-term follow-up (more than 1 year); and (3) with available 3D scanning data.

A total of 24 patients (n = 35 breasts) (from 2017 to 2021) with mild or moderate breast ptosis undergoing primary internal suture mastopexy combined with prosthetic augmentation and 24 patients (n = 48 breasts) (from 2018 to 2021) undergoing simple primary dual-plane breast augmentation were enrolled in the study. Internal sutures were placed by using the periareolar approach. In the retromammary space, the upper pole was fully dissected to the level of the second rib, while the lower pole was minimally dissected to maintain the adhesion of the breast tissue and pectoralis major muscle. In the subpectoral space, the pocket was dissected according to the size of the implant. The fibers of the pectoralis major muscle were separated between 4 and 8 o′clock to form the dual-plane. The muscle was perfectly divided and retracted to the level just slightly inferior to the nipple-areola complex (NAC). Based on the location of the retracted pectoralis major muscle, we judged that the operation should be performed using either the type I dual-plane technique or the type II dual-plane technique. A permanent suture (0 silk, Mersilk, Johnson & Johnson Co., USA) was placed through the pectoralis major muscle at the level of the second intercostal parasternal line before the implant was inserted into the subpectoral pocket. After the implant position was displaced, a second thread was put through the mammary gland, just above the edge of the NAC. The pectoralis sutures are tied to the breast sutures, lifting the upper pole of the mammary gland into a higher position. The tightness of the two stitches was adjusted to ensure that the nipples and submammary folds were raised. After surgery, conventional elastic bandages were used for compression dressing, and an extra elastic band was applied to the upper breast to promote dislocation adhesion of the breast tissue. All procedures were performed by corresponding authors according to standard surgical approaches. All the patients were Chinese women. Personal data, including age and implant size, were collected for both groups. One of the authors evaluated the preoperative and postoperative photos and categorized them according to the Regnault ptosis degree.

3D Surface Imaging

The 3D breast surface images of each patient were obtained preoperatively (pre-op) and postoperatively (post-op). All 3D breast surface imaging was performed using a Vectra XT (Canfield Scientific, Inc., USA) system based on a standard 3D scanning protocol. The 3D breast model was measured and analyzed using software (Geomagic Studio 11) as previously reported [5].

Linear Distance Measurements

The following linear distance measurements between specific anatomical markers on the 3D model surface were acquired in both groups automatically by software: sternal notch to nipple (SN–N); nipple to midline (N–M); and sternal notch to the level of the inframammary fold (SN–LIMF).

Breast Volume Measurements and Volumetric Distribution

The total breast volume of each 3D surface model was calculated, as previously described [6]. A transverse plane was placed through the nipple to divide the breast into upper and lower poles. The distribution of tissue at the upper and lower poles was determined by calculating the percent volume above and below this plane.

Changes in Breast Projection and Nipple Position

The preoperative scan was used as the reference model, and the postoperative scan was superimposed on the reference model according to specific anatomical sites to quantify the changes in breast projection and nipple position. A sagittal section at each nipple was used to determine the maximum breast projection point, and the change in breast projection was calculated as the change in the vertical height of the maximum breast projection. Furthermore, changes in the position of the nipple in terms of the linear distance in three dimensions were measured using the X-, Y-, and Z-axis as the coordinate system, as previously described [7]. The upward, medial and forward displacement of the nipple is defined as positive movement.

Statistical Analysis

All data are presented as the mean value ± standard deviation (SD). Pre- and postoperative values were compared using two-tailed paired T tests (significance level: $p < 0.05$). Two groups of values were compared using two-tailed independent-samples T tests (significance level: $p < 0.05$). Analyses were performed using SPSS 21.0 software (Chicago, IL, USA).

Results

Patient and Implant Characteristics

Subject demographics and implant data are shown in Table 1. The mean age and body mass index (BMI) was 33.1 ± 5.9 years (range: 22–45 years) and 19.5 ± 1.7 kg/m^2 in the combined augmentation group and 31.4 ± 5.1 years (range: 24–44 years) and 19.1 ± 1.6 kg/m^2 in the simple augmentation group, respectively. Patients in both groups underwent surgical implantation with McGhan (Allergan Co., USA) or Mentor (Johnson & Johnson Co., USA) anatomical textured silicone prostheses and were followed up for more than 12 months. No complications, such as hematoma, infection, capsular contracture, or implant misplacement, occurred in any patient.

Linear Distance Measurements

The SN–N distance significantly decreased by 0.6 cm (21.2 ± 1.5 cm to 20.6 ± 1.2 cm) in the combined augmentation group. In contrast, the SN–N distance increased by 1.0 cm (17.9 ± 1.4 cm to 18.8 ± 1.6 cm) in the simple augmentation group. The N–M distance significantly increased after simple breast augmentation (8.4 ± 0.9 cm to 9.3 ± 1.0 cm), while there was no significant difference in the N–M distance after internal suture mastopexy (9.7 ± 0.8 cm to 9.9 ± 0.9 cm). Furthermore, the SN–LIMF distance significantly decreased by 0.9 cm (23.7 ± 1.4 cm to 22.8 ± 1.0 cm) in the combined augmentation group, while the SN–LIMF distance increased by 0.5 cm (21.6 ± 1.4 cm to 22.1 ± 1.4 cm) in the simple augmentation group (Figs. 1 and 2 and Table 2). There were statistically significant differences in all linear distance measurements between the two groups before and after surgery ($p < 0.05$).

Breast Volume Measurements and Volumetric Distribution

In both groups, the breast volume significantly increased after surgery, with a mean increase of 199.0 ml after internal suture mastopexy and 218.0 ml after simple breast augmentation. The combined augmentation group showed a preoperative volume distribution of 40.1% in the upper pole and 59.9% in the lower pole. After the surgery, the upper pole volume increased by an average of 10.6%, resulting in a correction of the upper pole volume

Table 1. Demographic and implant data

	Internal suture mastopexy	Simple breast augmentation	P value
Number of breasts	35	48	–
Average age (year)	33.1 ± 5.9	31.4 ± 5.1	0.30
Average BMI (kg/m^2)	19.5 ± 1.7	19.1 ± 1.6	0.36
Pseudoptosis (%)	68.6%	4.2%	–
Ptosis degree I (%)	22.9%	4.2%	–
Ptosis degree II (%)	8.6%	0	–
Average follow-up (month)	16.2 ± 5.0	15.7 ± 4.8	0.73
Average implant size (ml)	246.3 ± 45.9	250.4 ± 36.9	0.65
Average implant projection (cm)	4.4 ± 0.5	4.3 ± 0.3	0.72

*Statistically significant ($p < 0.05$)

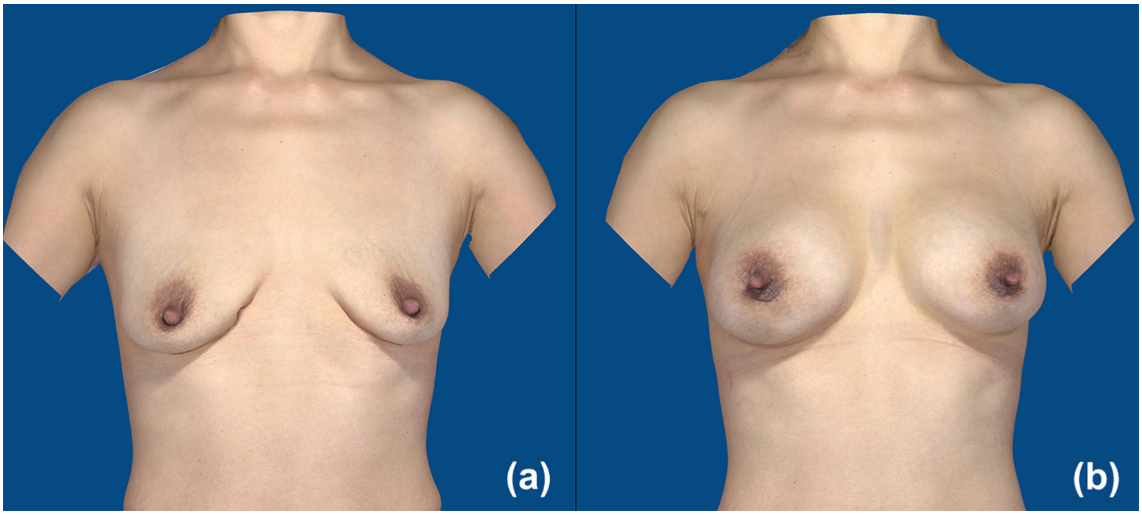


Fig. 1. Preoperative **a** and postoperative **b** 3D images of a 38-year-old patient with mild ptosis undergoing bilateral internal suture mastopexy augmentation through periareolar incision

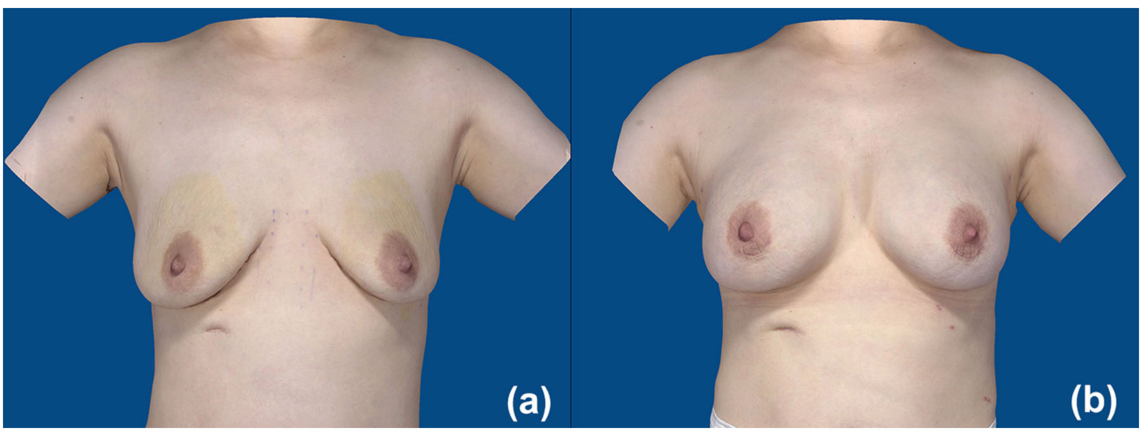


Fig. 2. Preoperative **a** and postoperative **b** 3D images of a 32-year-old patient with mild ptosis undergoing bilateral internal suture mastopexy augmentation through periareolar incision

distribution to 50.7%. The volumetric distribution of the upper poles decreased by an average of 2.2% in the simple breast augmentation group, with a preoperative average of 46.7% and a postoperative average of 44.5% in the upper pole (Table 2 and Fig. 3).

Changes in Breast Projection and Nipple Position

The average preoperative breast projection was 2.2 ± 0.8 cm in the combined augmentation group and 1.3 ± 0.6 cm in the simple group ($p < 0.05$). The average breast projection increased significantly by 2.7 ± 0.5 cm in the combined group and by 3.0 ± 0.4 cm in the simple group ($p < 0.05$). After surgery, the measured breast projections were 25.8 ± 2.2% lower than expected in the combined group and 23.2 ± 4.1% lower than expected in the simple group, based on implant parameters recorded by the manufacturer ($p < 0.05$) (Fig. 4). The changes in the nipple position in the three axial directions after surgery were statistically significant in both groups. Twelve months postoperatively, the nipple moved 0.2 ± 0.5 cm laterally, 1.6 ± 0.6 cm upward, and 2.8 ± 0.7 cm anteriorly in the combined group and 0.9 ± 0.5 cm laterally, 0.7 ± 0.6 cm upward, and 3.0 ± 0.6 cm anteriorly in the simple group (Table 2 and Fig. 5). The comparison of the movement of the nipple on the X- and Y-axis was significant ($p < 0.05$), however the movement of the nipple on the Z-axis was not significant ($p > 0.05$).

Table 2. Pre- and postoperative breast measurements (Mean ± standard deviation (SD) for all patients and both surgical techniques: liner distance measurements (cm) between specific landmarks (sternal notch to nipple (SN–N); nipple to midline (N–M); and sternal notch to the level of the inframammary fold (SN–LIMF)), breast volume (ml) and volume distribution, breast projection and the changes in the nipple position

	Combined augmentation group		Simple augmentation group	
	Pre-op	Post-op	Pre-op	Post-op
Linear distance measurements (cm)				
SN–N	21.2 ± 1.5	20.6 ± 1.2	17.9 ± 1.4	18.9 ± 1.7
N–M	9.7 ± 0.8	9.9 ± 0.9	8.4 ± 0.9	9.3 ± 1.0
SN–LIMF	23.7 ± 1.4	22.8 ± 1.0	21.7 ± 1.4	22.1 ± 1.5
Projection (cm)				
Projection	2.2 ± 0.8	4.9 ± 0.6	1.3 ± 0.6	4.3 ± 0.3
Breast volume measurements and volumetric distribution (ml)				
Total	145.7 ± 29.0	344.7 ± 36.1	54.7 ± 30.6	272.6 ± 42.5
Upper pole	62.8 ± 14.3	174.5 ± 19.7	25.5 ± 14.0	123.8 ± 18.8
Upper/total	43.1%	50.7%	46.7%	44.5%
Lower pole	83.0 ± 17.7	170.2 ± 22.0	29.2 ± 16.6	151.6 ± 25.0
Lower/total	56.9%	49.3%	53.3%	55.5%
Nipple position (cm)				
X-axis	0.2 ± 0.5		0.9 ± 0.5	
Y-axis	1.6 ± 0.6		0.7 ± 0.6	
Z-axis	2.8 ± 0.7		3.0 ± 0.6	

*Statistically significant ($p < 0.05$)

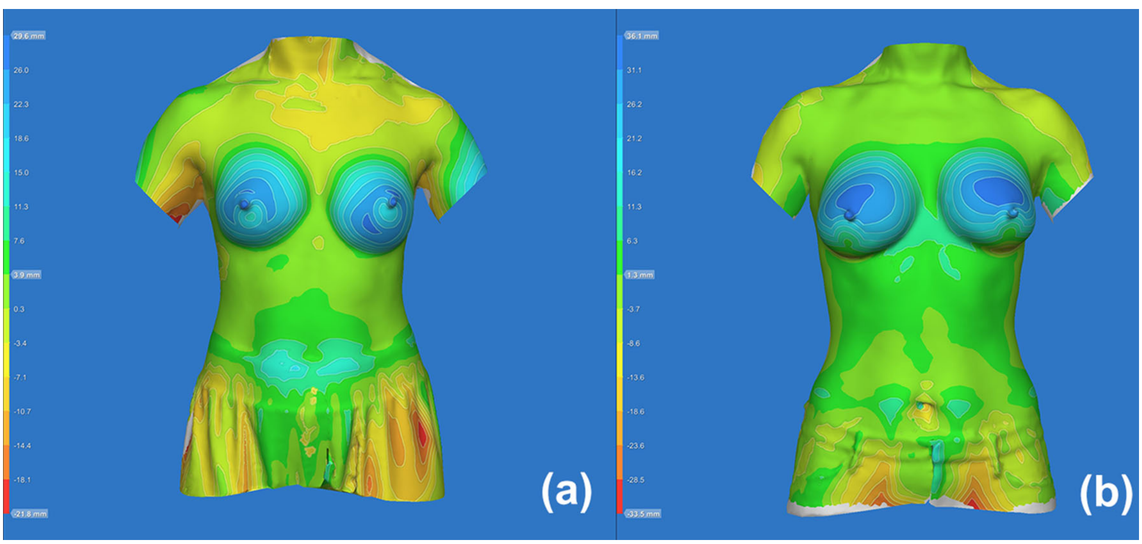


Fig. 3. Surface distance deviations of internal suture mastopexy augmentation **a** and primary augmentation **b** preoperatively and postoperatively. Note the mammary migration to the upper poles of the breast

Discussion

*A*fter breastfeeding, women often experience breast atrophy, accompanied by breast ptosis of different grades, which seriously affects the appearance of the breast, resulting in physical and psychological pain in patients. According to the Regnault classification, the grade of ptosis ranges from I to III [8]. True ptosis occurs when the NAC drops to or below the inframammary fold. In patients with breast atrophy and ptosis, it is necessary to correct both problems at the same time. Surgical correction requires an increase in breast volume and elevation of breast tissue.

Mild and moderate breast ptosis including pseudoptosis and grade I to II ptosis according to Regnault classification are common in clinical practice. Several surgical procedures for breast reshaping, including mastopexy, augmentation, and augmentation combined with mastopexy, have been described.

Mastopexy includes multiple skin incision design, parenchymal fixation, and redistribution options [9].

Fig. 4. Comparison of preoperative breast projection, implant projection, expected postoperative breast projection, and real postoperative breast projection (cm) in the two groups (simple augmentation group vs. simple augmentation group)

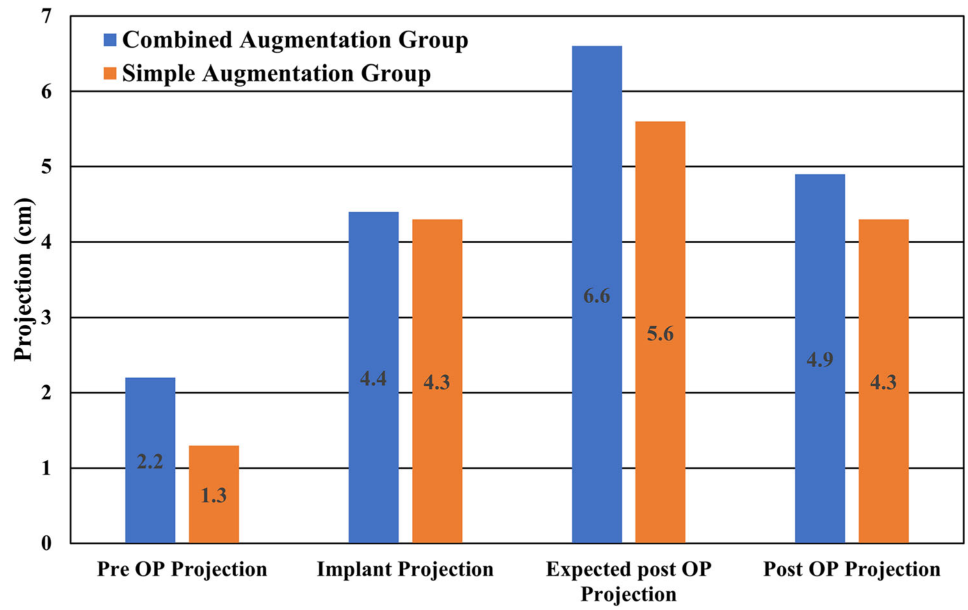
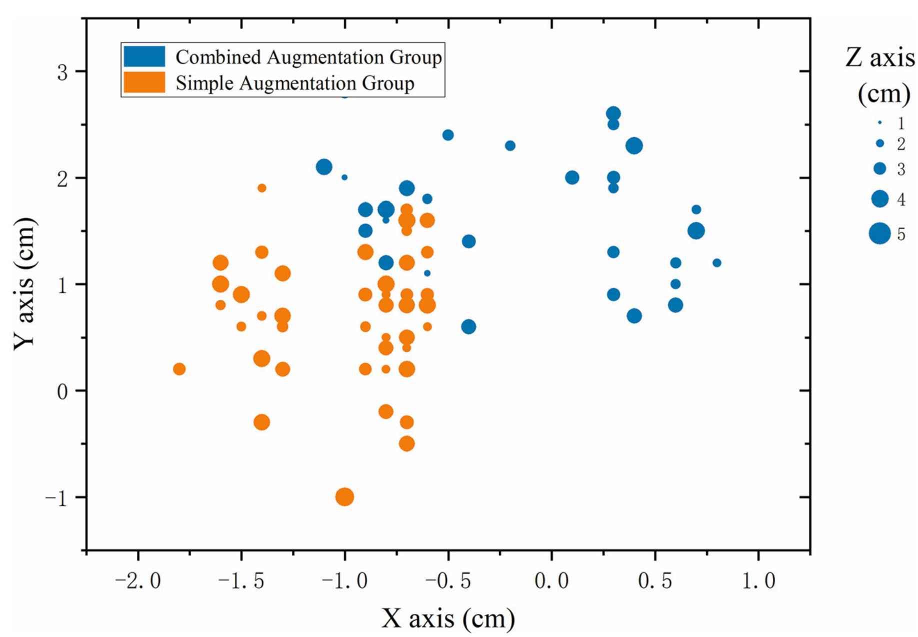


Fig. 5. The changes in the nipple position in the three axial directions after surgery. Note the positive magnitude of the values on the X-axis indicating combined breast augmentation pulls the nipple upward and inward, while simple breast augmentation pulls the nipple upward and outward



Although these surgeries can improve the shape of the breast, they cannot significantly correct volume deficiency. At present, mastopexy is being used to correct severe breast ptosis.

Due to these limitations in terms of increasing the breast projection and elevating the nipple position, augmentation combined with mastopexy has been proposed. Several studies have reported the advantages of single-stage augmentation-mastopexy to achieve the desired lifting effect and optimal aesthetic results [10–13]. In contrast, some authors have reported that the combined procedure may lead to a high rate of various postoperative complications, such as nipple-areola complex blood circulation disorders, loss of nipple sensation, areola deformation and implant misalignment and extrusion [14]. A 10-year prospective study revealed a complication rate of 36.3% for augmentation combined with mastopexy and 33.3% for mastopexy alone [15]. In addition, there is a high incidence of secondary surgical repair due to complications such as recurrence of breast ptosis [16].

Some researchers have reported that augmentation alone can be used to correct breast ptosis [17, 18]. Luan found that the nipple moved 0.6 cm upward after dual-plane augmentation [19]. However, Hall–Findlay [20] found that the position of the nipple dropped 2 cm on average after augmentation, while Tepper et al. [21] and Swanson [22] both found that the position of the nipple remained unchanged after augmentation. Therefore, whether breast augmentation alone can correct mild to moderate ptosis remains controversial. The measurement results of this study showed that the nipple position on the vertical axis was slightly raised by 0.7 cm after dual-plane breast augmentation. Therefore, we believe that simple breast augmentation with a prosthesis alone can improve the symptoms of breast ptosis, but with *a* is very limited effect. Gryskiewicz [17] explained that the nipple lifting effect after simple breast augmentation is due to the extension of the area between the nipple and the inframammary fold when the prosthesis is placed in the pocket, which elevates the nipple like a pendulum. The breast ptosis has not been truly corrected, and the postoperative breast shape makes it difficult to meet the aesthetic requirements of patients. Therefore, mild and moderate breast atrophy and ptosis need to be corrected by other techniques combined with mammoplasty.

In 2020, we proposed a "breast augmentation combined with internal suture mastopexy" technique to correct mild to moderate ptosis and atrophy [1]. This procedure is suitable for patients with insufficient breast volume and mild or mild to moderate ptosis. This procedure is best for simultaneously correcting breast ptosis and in the following instances: (1) When the nipple should be located within 1 cm inferior to the plane of the lowest part of the inframammary fold; (2) when the distance between the lowest part of the breast tissue below the inframammary fold and the inframammary fold should be $\leq$ 3 cm; and (3) when the distance between the nipple and the inframammary fold should be $\leq$ 10 cm. The effect of the procedure is compromised, if only one or two conditions are met. This method is not suitable for patients who do not meet any of the above conditions. With this technique combined with dual-plane breast augmentation, the upper mammary tissue above the areola can be suspended, folded, and fixed to promote the upward movement of the lower mammary tissue, increase the percent volume of the upper pole of the breast, lift the nipple-areola complex, conceal the postoperative traces of the incision, and reduce the probability of breast ptosis recurrence. Nevertheless, only a simple tape measure-based system was applied to measure breast morphometry to verify the efficacy of this technique. This tape measure-based system limits the assessment of complex 3D features of the breast, including shape, volume, upper and lower pole volume distribution, and projection. 3D scanning is widely used in the preoperative and postoperative evaluation of breast morphology because it can record the 3D morphology of breasts with good accuracy and repeatability [23–25].

In this article, we examined the breast morphological changes after internal suture mastopexy combined with prosthetic augmentation compared with those after simple augmentation. Based on changes in linear measurements of the 3D model, the SN–N distance decreased by 0.6 cm after simultaneous breast augmentation and mastopexy. Conversely, the SN–N distance increased by 0.9 cm after simple breast augmentation, which is consistent with our previous findings. The N–M distance increased postoperatively, with a notable change of 0.9 cm postoperatively in the primary augmentation group. The N–M distance remained the same in the combined augmentation group, demonstrating that internal suture mastopexy moves the nipple medial and upward.

In addition, we assessed morphological changes in breast projection between before and after surgery and found that the measured values for breast projection were 25.8% lower than expected in the combined group and 23.2% lower than expected in the simple group, based on implant parameters recorded by the manufacturer. Tepper et al. [21] reported nearly 21% less projection than expected, and Kovacs et al. [26] reported 22% less than expected for round implants and 25% less than expected for anatomical implants. In our opinion, the thickness of breast tissue in patients with breast atrophy was greater than that in patients with micromastia alone, and the implants squeezed the breast tissue to a greater degree. This study provides important clinical information for surgeons in preoperative prosthesis selection, and our findings may encourage surgeons to choose more convex implants for patients with breast ptosis.

Ptosis is measured by the difference in the position of the nipple relative to the inframammary fold after surgery. Postoperative changes in the nipple and inframammary fold can lead to limitations in assessing the SN–N distance alone. In our study, the IMF level was elevated by 0.5 cm in the simple augmentation group and was lowered by 0.9 cm in the combined augmentation group. In contrast to simple breast augmentation, combined breast augmentation pulls the nipple upward and medial. Thus, we believe that the relationship between the nipple and the IMF level can be balanced by adjusting the preoperative design of the new IMF and the internal lifting fixation site. A recent study in Columbia using social media concluded that centrally located nipples are preferred by all groups of people [27]. Therefore, surgeons should try to conservatively dissect the outside of the subpectoral pocket during internal suture mastopexy to ensure that the postoperative nipple is located in the center of the breast.

We also measured changes in breast volume and volume distribution between the upper and lower poles, since total breast volume loss and inadequate upper pole fullness are major anatomical markers of breast ptosis requiring correction. In 2012, Eder et al. [28] first used breast tissue migration to describe volume changes in the upper and lower poles of the breast. We used a transverse plane placed through the nipple level to divide the breast region into the upper and lower poles. We found that the volume ratio of the upper to the lower breast pole changed from 4:6 to 1:1 after internal suture mastopexy. Mallucci and Branford [29] first suggested that the ideal proportion of the upper to the lower pole is 45:55. With the development of breast aesthetics research, Chen et al. [30] found that the ideal shape of the lower pole of the breast is hemispherical, with the upper and lower poles having the same volume. Hsia and Thomson [31] also reported that a fuller upper pole is preferred by patients. There is reason to believe that a fuller upper pole is more aesthetic and can help prevent recurrence of breast ptosis with time.

This study was limited by a specific implant surface. The results can be very different with a round, smooth surface implant. Therefore, the focus of future studies will be whether this conclusion can be generalized to other implant types. Second, this was a single-institution study conducted by an experienced plastic surgeon. This may limit the generalization of the findings. Future multicenter studies will be conducted to reduce any surgical technical bias caused by evaluating surgeons from a single center.

Conclusion

Internal suture mastopexy in addition to dual-plane breast augmentation appears to reposition breast tissue from the lower pole to fill in the deficient upper breast, pull the nipple medially and superiorly, and ultimately correct mild to moderate breast ptosis.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00266-022-03200-2.

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Declarations

Conflict of interest The authors declare that they have no conflict of interest to disclose.

Ethical Approval The study was approved by the Ethics Committee of Guangdong Second Provincial General Hospital.

Consent to Participate Written informed consent was obtained from every patient prior to the study.

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