

The Investigation of the Relation Between Expansion Strategy and Outcomes of Two-Stage Expander-Implant Breast Reconstruction

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Abstract

Numerous risk factors for the complications of two-stage, immediate implant-based breast reconstruction have been identified, although few studies have directly examined the impact of breast size and expansion protocols on the surgical outcomes of breast reconstruction. This study aimed to evaluate the impact of breast size, expansion velocity, and volume-related variables on postoperative complications of breast reconstruction.

The cohort involved patients who underwent immediate breast expander reconstruction at a single center between 2017 and 2019. The breast size was classified into three categories according to the weight of the mastectomy specimen as small (< 300 g), medium (≥ 300 g, ≤ 500 g), or large (> 500 g). Multifactorial logistic regressions were used to assess the impact of variables, and receiver operating curve (ROC) analysis was used to determine the optimal cut-off value for predicting the complication event.

Of the 174 breasts (168 patients), 51 (29.3%), 66 (37.9%), and 57 (32.6%) breasts were classified as small, medium, and large, respectively. The rate of infection ($p = 0.014$) and expander/implant failure ($p = 0.007$) significantly differed according to breast size, with the rate being the highest in large breasts. Multivariate logistic regression analysis showed that body mass index (odds ratio [OR]: 1.25, $p = 0.003$), nipple-sparing mastectomy (OR: 2.82, $p = 0.036$), sentinel biopsy (OR: 5.10, $p = 0.016$), final expansion volume (OR: 0.99, $p = 0.022$), and expansion velocity (OR: 0.703, $p = 0.024$) were significant independent predictors of any complication. In the ROC analysis, breast weight > 696 g could predict the possibility of revision surgery, with a sensitivity of 42.9% and specificity of 81.8%.

The final expansion volume and expansion velocity have a significant negative relationship with overall complications in breast reconstruction. A standard expansion protocol needs to be established to ensure the success of two-stage breast reconstruction.

Introduction

The increasing rate of breast cancer has also increased the number of postmastectomy breast reconstructions performed. In the past, breast reconstruction was performed as a delayed procedure largely because of concerns that the reconstructive process would compromise adjuvant oncologic treatment such as chemo-or radio-therapy[1]. However, current strategies of surgical breast reconstruction can achieve both satisfactory therapeutic and cosmetic results[2]. Implant-based breast reconstruction is associated with superior aesthetic benefits and rapid patient recovery. However, its use is limited in patients indicated for postmastectomy radiation therapy. These patients have weak connective tissues and inadequate soft-tissue coverage, leading to skin breakdown, implant exposure, and suboptimal aesthetic outcomes with firm, high-riding breasts with poor symmetry[3, 4]. Tissue response to radiation exposure varies temporally[5], and the most common cause of breast reconstruction failure is long-term radiation-induced tissue injury. Thus, a two-stage breast reconstruction technique that has the

advantages of minimizing the radiation effect and maximizing implant aesthetics has been introduced. The two-stage implant-based reconstruction performed immediately after mastectomy is currently the preferred method owing to its advantages of improved aesthetic results, equivalent oncologic outcomes, and decreased costs. It is also the optimal strategy for breast surgery with autologous breast reconstruction[6].

Several factors influence the outcomes of two-stage breast reconstruction. Smoking, obesity, and the reconstructive method have been reported to associate with the risk of complications in implant-based reconstruction[7]. In addition, the size of the breast remains a challenge in expander reconstruction[8]. A large breast size yields a larger surface area for the mastectomy flap, increasing the possibility of impaired perfusion and ischemic sequelae with subsequent reconstruction. Another influencing factor of the surgical outcomes of two-stage breast reconstruction is the expansion protocol. Although several trials have supported the usefulness of reconstructive surgery, clinical evidence on the expansion protocol is still limited. Initial saline administration immediately after expander insertion increases its final volume to up to 20–30%, while other studies have reported complete deflation[9]. The completion of chemotherapy and/or radiotherapy also varies. Further, the expander inflation interval and maximal inflated volume can also differ.

Further, patient care differs between immediate and delayed breast reconstruction, and the expansion protocol, including inflation, deflation volume, and expansion velocity, differs by patient. However, few studies have directly examined the impact of breast size and expansion protocols on the surgical outcomes of breast reconstruction. Thus, the purpose of our study was to evaluate the effect of expansion protocol, including breast size and expansion velocity, on the risk of complications in two-stage breast reconstruction surgery to elucidate the possible causes of reconstruction failure. To this end, the breast was classified by size and the rate of complications was compared among groups. The risk factors of surgical complication were also investigated.

Methods

Study design and patients

This retrospective study evaluated patients who underwent immediate breast expander reconstruction at a single center (O000 University Hospital, Suwon, Republic of Korea) between 2017 and 2019. Patients who underwent two-stage prosthetic breast reconstruction (tissue expander followed by permanent implant) following modified radical mastectomy and with a minimum of 6 months of postoperative follow-up were included. Age, body mass index (BMI), cancer profile and stage, volume of mastectomy specimen, initial and final expander volume, history of radiation therapy and/or chemotherapy, history of diabetes and other comorbidities, history of smoking, and the occurrence of complication were recorded for each patient. For patients who underwent bilateral breast reconstruction, data from each breast were recorded as an independent point.

Given that breast size is the primary consideration in expander-based breast reconstruction, breast size was stratified into three categories according to the weight of the specimen for total mastectomy: small breast, specimen weight < 300 g[10]; medium, 300–500 g; and large, > 500 g[11, 12]. This study was approved by the Institutional Review Board (IRB) of Ajou University Hospital, Suwon, Korea (IRB No. AJIRB-MED-MDB-21-235) and was conducted according to the tenets of the Declaration of Helsinki. The need for informed consent was waived owing to the retrospective nature of the research. However, consent to obtain and to publish relevant images was obtained from all participants. The contents were included in the consent form for surgery.

Reconstruction technique

All patients underwent immediate breast reconstruction following modified radical mastectomy with placement of subpectoral or prepectoral tissue expander. The device was partly placed into a space created beneath the pectoralis major muscle supero-medially and the infero-lateral surface of the expander was covered with acellular dermal matrix (CG-cryoderm®, CGBio Corp., Seongnam, Republic of Korea). The size of the acellular dermal matrix ranged from 60 cm² to 324 cm². Complete coverage with muscular and acellular dermal matrix was considered to protect the tissue expander and to help conceal the flaws of the permanent implant.

In the case of insertion at the prepectoral plane, the whole surface of the expander was covered with the acellular dermal matrix. After placement of the expander and completion of suturing, normal-saline with indigo carmine was injected into the expander for initial inflation, depending on the condition of patient's mastectomy flap. This completed the first surgery. Expander fillings were usually initiated 2–4 weeks after surgery and were performed using chlorhexidine preparation of the port site. Patients receiving adjuvant chemotherapy underwent expansion throughout the duration of chemotherapy. Patients requiring adjuvant radiation therapy underwent rapid expansion followed by radiation therapy[13].

The second stage of the reconstruction comprised removal of the tissue expander, a capsulotomy and capsulectomy, followed by the placement of a permanent silicone gel and autologous fat graft for supero-medial side depression if necessary. Radiotherapy and chemotherapy were performed either before the first surgery or after completion of the second surgery(Fig. 1). For patients with a history radiation therapy, the second stage of reconstruction was delayed until at least 3 months from the completion of the radiation therapy for full wound healing from radiation injury(Fig. 2).

Study variables

The factors of the expansion protocols were then evaluated (Fig. 3). The mastectomy volume (cc) and weight (g) were recorded after mastectomy by general surgery-team. The serial skin expansion from the first to the second surgery, expansion volume and its interval, and final inflation volume (cc) were also recorded. The final implant volume and postoperative follow up status were determined. Expansion velocity was calculated by subtracting the initial inflation volume from the final inflation volume and dividing this by the inflation period as follows:

$$\text{Expansion velocity} = \frac{\text{Final inflation volume (cc)} - \text{Initial inflation volume (cc)}}{\text{Inflation period (days)}}$$

Assessments

Complications of infection, seroma and/or hematoma, skin necrosis including nipple, and wound dehiscence were recorded. Infections were defined as surgical events that needed additional intravenous antibiotics or ex-plantation at least 2–3 weeks after surgery. Expander/implant failure was defined as any type of infection-related device failure, including spontaneous rupture or inadvertent iatrogenic puncture, displacement of the device requiring revision, painful capsular contracture, and exchange for another prosthesis. Revision surgery was defined as a minor surgical procedure (e.g., debridement or repair) for any complication.

Statistical analyses

Continuous variables were presented as the means and standard deviations and were compared using the t-test. Meanwhile, categorical variables were presented as frequencies and percentages and were compared using the chi-square and Fisher's exact tests. The risk factors for overall complication were first identified through a univariate analysis, and significant variables (i.e., those with a p -value < 0.05) were included in the multivariate analysis. Backward-stepwise logistic regression analysis was performed to identify risk factors for surgical complication. Receiver operating characteristic (ROC) curve analysis was used to determine the optimal cut-off value predictive of the complication event. All statistical analyses were performed using SPSS Version 19.0 (IBM Corp., Armonk, N.Y.). A p -value of < 0.05 was considered statistically significant.

Results

Patient and breast characteristics

A total of 168 patients and 174 breasts with a mean age of 43.39 years (range, 24–75 years) were evaluated. The mean BMI was 22.37 kg/m² (range, 15.7–31.2 kg/m²). The most prevalent cancer type was invasive ductal cell carcinoma (52.9%), followed by ductal carcinoma in situ (33.9%). Overall, 18.4% of the patients had comorbid conditions (i.e., controlled diabetes, hypertension, and thyroid disease), and only 3 patients were current smokers. Of the 174 breasts (168 patients), 51 (29.3%), 66 (37.9%), and 57 (32.6%) breasts were classified as small, medium, and large, respectively. The mean weight and volume for small breasts were 217.43 kg and 232.54 cc; medium breasts, 399.43 kg and 427.65 cc; and large breasts, 693.89 kg and 748.15 cc, respectively. Obesity (BMI > 30 kg/m²) was observed in patients with large breasts (15.69%) alone. The most common type of mastectomy for medium and large breasts was nipple-sparing mastectomy (60.6% in medium group and 54.4% in large group respectively), whereas it was skin-sparing mastectomy in small breasts (39.2%). Neoadjuvant radiotherapy was more commonly performed in small and medium breasts, while adjuvant radiotherapy was more frequent in large breasts.

Chemotherapy was primarily performed in the neoadjuvant setting in small (23.52%) and large breasts (31.58%), respectively (Table 1).

Table 1

Patient demographics and mastectomy-related variables stratified by size of breast determined by weight of mastectomy-specimen

Breast size			
Variables	Small breast (%)	Medium breast (%)	Large breast (%)
No. of breasts = 174	51 (29.31)	66 (37.93)	57 (32.57)
Mastectomy (mean, min/max)			
Weight (kg)	217.43 (55–290)	399.43 (300–490)	693.89 (490–1220)
Volume (cc)	232.54 (60–310)	427.65 (320–530)	748.15 (520–1400)
Patient variables (mean ± SD)			
Age (yr)	41.01 ± 8.49	44.88 ± 10.97	44.60 ± 44.14
Weight (kg)	52.18 ± 5.30	56.44 ± 5.85	63.89 ± 8.56
BMI (kg/m ²)	20.12 ± 2.25	21.92 ± 3.30	24.93 ± 3.42
Obese (BMI ≥ 30 kg/m ²)	0	0	8 (15.69)
Never smoker	52 (91.23)	64 (96.96)	50 (98.04)
Current smoker	3 (5.26)	0	0
DM	0	2 (3.03)	0
HTN	2 (3.50)	5 (7.58)	7 (13.73)
Previous breast operation	12 (23.53)	10 (15.15)	4 (7.02)
Pathology			
Invasive ductal carcinoma	28 (49.12)	35 (53.03)	29 (56.86)
Ductal carcinoma in situ	17 (29.82)	28 (42.42)	14 (27.45)
Invasive lobular carcinoma	3 (5.26)	3 (4.55)	4 (7.84)
Spindle cell tumor	1 (1.75)	0	3 (5.88)
*Others	2 (3.51)	0	7 (13.73)
Stage			
0	13 (25.49)	0	0
I	17 (33.33)	30 (45.45)	27 (47.37)
II	14 (27.45)	26 (39.39)	22 (38.60)
*Other pathologies: Mucinous carcinoma, papillary carcinoma, myxoid tumor, Paget's disease			

Breast size			
□	7 (13.72)	10 (15.15)	8 (14.06)
Neoadjuvant/adjvant therapy			
Neoadjuvant radiation therapy	5 (9.80)	7 (10.60)	1 (1.75)
Adjuvant radiation therapy	9 (17.64)	7 (10.60)	17 (29.82)
Neoadjuvant chemotherapy	12 (23.52)	13 (19.70)	10 (17.54)
Adjuvant chemotherapy	18 (35.29)	19 (28.79)	18 (31.58)
Breast surgeon			
Surgeon 1	31 (60.78)	40 (60.61)	37 (64.91)
Surgeon 2	14 (27.45)	13 (19.70)	10 (17.54)
Surgeon 3	6 (11.76)	13 (19.70)	10 (17.54)
Type of mastectomy			
Skin sparing	20 (39.21)	23 (34.85)	20 (35.09)
Nipple sparing	26 (50.98)	40 (60.61)	31 (54.39)
Radical (modified)	5 (9.80)	3 (4.55)	6 (10.53)
Lymph nose dissection			
(-)	7 (13.73)	4 (6.06)	6 (10.53)
Axillary	14 (27.45)	15 (22.73)	14 (24.56)
Sentinel	30 (58.82)	47 (71.21)	37 (64.91)
*Other pathologies: Mucinous carcinoma, papillary carcinoma, myxoid tumor, Paget's disease			

Complications

Complications during the reconstruction period occurred in 72 breasts, with the most common being skin necrosis (24.7%). Other complications included surgical site infection (3.4%), seroma or hematoma (11.5%), revision surgery (9.7%), and expander/implant failure (4.0%). The rate of any complications was 41.3% (Table 2). The rates of surgical site infection ($p = 0.014$) and expander/implant failure ($p = 0.007$) significantly differed according to breast size, with the rates being the highest in large breasts.

Meanwhile, skin necrosis was significantly more frequent in medium breasts ($p = 0.026$). The rates of seroma/hematoma and skin necrosis were also higher in small breasts, although the difference was not significant ($p = 0.255$ and 0.296 , respectively). Revision surgery was more frequently performed in large breasts, although the difference did not reach significance ($p = 0.104$).

Table 2
Postoperative complications based on breast size

Complication	Small breast (%)	Medium breast (%)	Large breast (%)	<i>p</i> -value
No. of patients	51	66	57	
Infection	3 (5.88)	1 (1.52)	4 (7.01)	0.014*
Seroma/hematoma	7 (13.76)	7 (10.60)	6 (10.53)	0.255
Skin necrosis	13 (25.49)	16 (25.75)	13 (22.80)	0.026*
Revisionary operation	3 (5.88)	5 (7.58)	9 (15.79)	0.104
Expander/implant failure	2 (3.92)	1 (1.52)	3 (5.26)	0.007*
Overall complication event	19 (37.25)	26 (39.39)	27 (47.37)	0.645
*Statistically significant				

Risk factors of complications

Univariate logistic regression analysis identified body mass index, breast volume, weight, radiation, chemotherapy, type of mastectomy, type of lymph node dissection, and expander characteristics as significant variables of complications. In multivariate logistic regression analysis, BMI (odds ratio [OR]: 1.25, 95% confidence interval [CI]: 1.08–1.44, $p = 0.003$), nipple-sparing mastectomy (OR: 2.82, 95% CI: 1.07–7.45, $p = 0.036$), sentinel lymph node biopsy (OR: 5.10, 95% CI: 1.36–19.11, $p = 0.016$), final expansion volume (OR: 0.99, 95% CI: 0.99–1.00, $p = 0.022$), and expansion velocity of the expander (OR: 0.703, 95% CI: 0.52–0.95, $p = 0.024$) were significant independent predictors of any complication (Table 3). Interestingly, a large final expansion volume and rapid expansion velocity of expander negatively influenced the occurrence of overall complications.

Table 3
Multivariate logistic regression analysis of the risk factors of overall complications in two-stage breast reconstruction

Variables	OR (95% CI)	p-value
BMI (kg/m ²)	1.25 (1.08–1.44)	0.003*
Breast volume	1.01 (1.03–0.99)	0.158
Breast weight	0.98 (1.00-0.96)	0.209
Adjuvant radiation therapy	2.72 (0.91–8.15)	0.073
Neoadjuvant chemotherapy	2.38 (0.93–6.10)	0.072
Type of mastectomy		
Skin sparing	1.00	0.072
Nipple sparing	2.82 (1.07–7.45)	0.036*
Radical (modified)	0.85 (0.17–4.37)	0.850
Lymph nose dissection		
No	1.000	0.053
Axillary	3.598 (0.76–16.87)	0.104
Sentinel	5.103 (1.36–19.11)	0.016*
Expander		
Final expansion volume (cc)	0.995 (0.99-1.00)	0.022*
Expansion velocity (cc/day)	0.703 (0.52–0.95)	0.024*
*Statistically significant		

Using breast weight, breast volume, and expansion velocity, Receiver operating characteristic (ROC) analysis showed the cut-off value for each complication. Among complications and rate of revision surgery, only the ROC curve for the revision surgery was found to be statistically significant (volume: area under the curve [AUC] = 0.693, $p = 0.017$; weight: AUC = 0.702, $p = 0.012$). Using this cut-off value, breast volume > 505 cc predicted the possibility of revision surgery, with a sensitivity of 64.3% and a specificity of 66.2%. Breast weight > 695 g also predict possibility of revision surgery, with a sensitivity of 42.9% and a specificity of 81.8% (Fig. 4).

Discussion

Data on the impact of breast size and expansion protocols on the surgical outcomes of breast reconstruction are scarce. In this study, a large breast size was associated with significantly higher rates

of infection and prosthetic failure, although skin necrosis was more frequent in medium breasts. In addition, the final expansion volume and expansion velocity were negatively associated with the occurrence of overall complications.

A weight of mastectomy-specimen of at least 800 g was reported to be associated with a higher rate of complications, including ischemia and infection[14]. A breast size larger than C cup is also significantly associated with postoperative infection[15]. Ambiguous understanding of the effect of large breast size on postoperative complications can lead to inaccurate outcome predictions. Among Asian women, we found that a large breast weight of mastectomy-specimen > 500 g increased the risk of implant failure rate, and a medium breast with weight of mastectomy-specimen, 300-500g increased the risk of skin necrosis. In nipple-sparing mastectomy, perfusion to the nipple-areola complex and mastectomy flap is achieved through vasculature in the subdermal and subcutaneous tissues[16]. A large breast size results in a larger surface area for the mastectomy flap, thus providing higher perfusion and leading to decreased ischemic sequelae[17]. However, for medium-sized breasts, the contact surface between the mastectomy skin flap and implant is smaller than in large breasts, increasing the probability of volume tension on the skin flap during the expansion period. Although this gap has a positive effect on reducing seroma or hematoma through compression, it also has a negative effect on the occurrence of skin necrosis.

High BMI, diabetic smoking, chemotherapy/radiation therapy, and planes of prosthetic insertion or the use of an acellular dermal matrix for implantation are well-known risk factors of postoperative complications[18]. Similarly, we found that high BMI, nipple-sparing mastectomy, and sentinel lymph node biopsy were independent risk factors. Patients with high BMI have poorer outcomes after breast reconstructive surgery than patients with normal BMI. A multicenter prospective study showed higher risks for overall and major complications in both implant-based and autologous breast reconstruction among obese patients than among underweight/normal-weight patients[8]. This could be because obese patients use their upper body, instead of their core body strength. The shearing caused by the repeated use of the pectoralis muscle for this maneuver in the immediate postoperative period could result in seroma formation in cases of subpectoral placement[8].

The effect of the expansion protocol on the postoperative period has been trivialized. However, interestingly, we found that a large final expansion volume and rapid expansion velocity help lower the occurrence of overall complications, highlighting that the expansion protocol has important effects on the surgical outcomes of two-stage breast reconstruction. Compared with the final expansion volume, the expansion velocity had a more protective effect on the occurrence of overall complications.

Faster expansion can more quickly reduce the dead space and interval to the second surgery; thus, it could shorten the time of biofilm-formation. Seromas following prosthetic breast reconstruction are complicated by the hypovascularity, pro-inflammatory milieu of the mastectomy skin flap, geometrically complex dead space, and presence of a foreign body with potential contamination and bio-film[19].

These factors contribute to the progression of seroma to infection and prosthesis loss[20]. Thus, reducing the chance of biofilm formation is strongly associated with reducing seroma and infection.

The effect of breast size should also be considered. Volume expansion may affect the tension on the skin flap, although it can also reduce seroma or hematoma through compression. Meanwhile, expansion velocity allows easier stretching of the skin flap, and a faster expansion velocity shortens the interval between the first and second surgeries. We found that a breast weight > 696 kg and breast volume > 505 cc increase the probability of revision surgery in the postoperative period. Thus, patients with these characteristics should be closely monitored.

The limitations of this study include its retrospective nature and the categorization of breast size according to the characteristics of Asian women. Thus, the results may have limited generalizability to women from Western countries. Furthermore, outcomes such as mastectomy flap necrosis were defined by intervention and thus influenced by surgeon preference. Notably, each complication also carries a different impact based on the reconstruction modality used. For example, mastectomy flap necrosis in implant-based nipple-sparing mastectomy has a higher risk of reconstructive failure than autologous reconstruction. However, the follow-up time was similar to that in other studies examining the outcomes of nipple-sparing mastectomy. Therefore, future research requires the following, a large group study in Asian patient group will be more meaningful, and long-term follow-up analysis will be needed to understand the effect on the capsular contracture and the resulting operation rate.

In conclusion, the final expansion volume and expansion velocity have a significant negative relationship with overall complications in breast reconstruction surgery. However, breast size can be used to predict the possibility of complications. A standard expansion protocol needs to be established to ensure a successful two-stage breast reconstruction.

Abbreviations

BMI (Body Mass Index), DM (Diabetes mellitus), HTN(Hypertension), OR (Odds Ratios), SD (Standard deviation)

Declarations

-Ethics approval and consent to participate*

: This study was approved by the Institutional Review Board (IRB) of Ajou University Hospital, Suwon, Korea (IRB No. AJIRB-MED-MDB-21-235). and was conducted according to the tenets of the Declaration of Helsinki

-Consent for publication

: Consent to obtain and to publish relevant images was obtained from all participants. The contents were included in the consent form for surgery

-Availability of data and material

: The dataset used and/or analyzed during the current study are available from the corresponding author on reasonable request.

-Competing interests

: The author declares no competing interests.

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-Authors' contributions

: Min Ji Kim - writing and editing

Woo Beom Lee - data acquisition

Il Jae Lee, Hyung Min Hahn - data curation, reviewing

Duy Quang Thai - investigation

Ji Young Kim - supervision

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: none

-Disclosures

The authors declared no potential conflicts of interest with respect to the research, authorship, and publication of this article.

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Figures

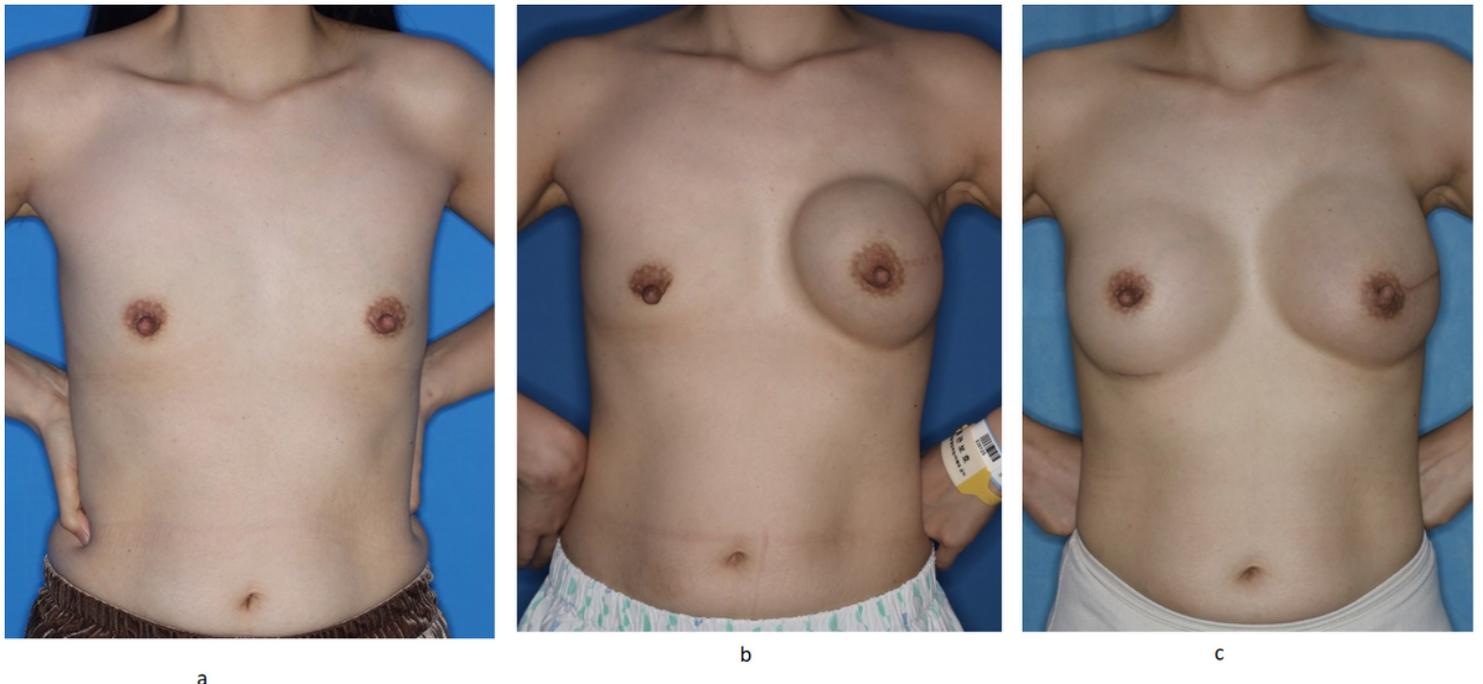


Figure 1

Representative case of two-stage expander-implant breast reconstruction following nipple-sparing mastectomy. A 38-year-old woman with left breast cancer, invasive ductal carcinoma, and a history of adjuvant chemotherapy underwent unilateral nipple-sparing mastectomy followed by immediate reconstruction with subpectoral insertion of a 350 cc tissue expander. The weight and volume of the mastectomy specimen were 240 g and 300 cc, respectively, and the initial fill volume was 130 cc. The final fill volume was 360 cc, and the expansion velocity was 230 cc/58 days. At 5 months after the expander surgery, she underwent a second surgery for expander/implant exchange with contralateral augmentation by silicone implant insertion. (A) Preoperative views. (B) Full expanded state. (C) 1 year after surgery.

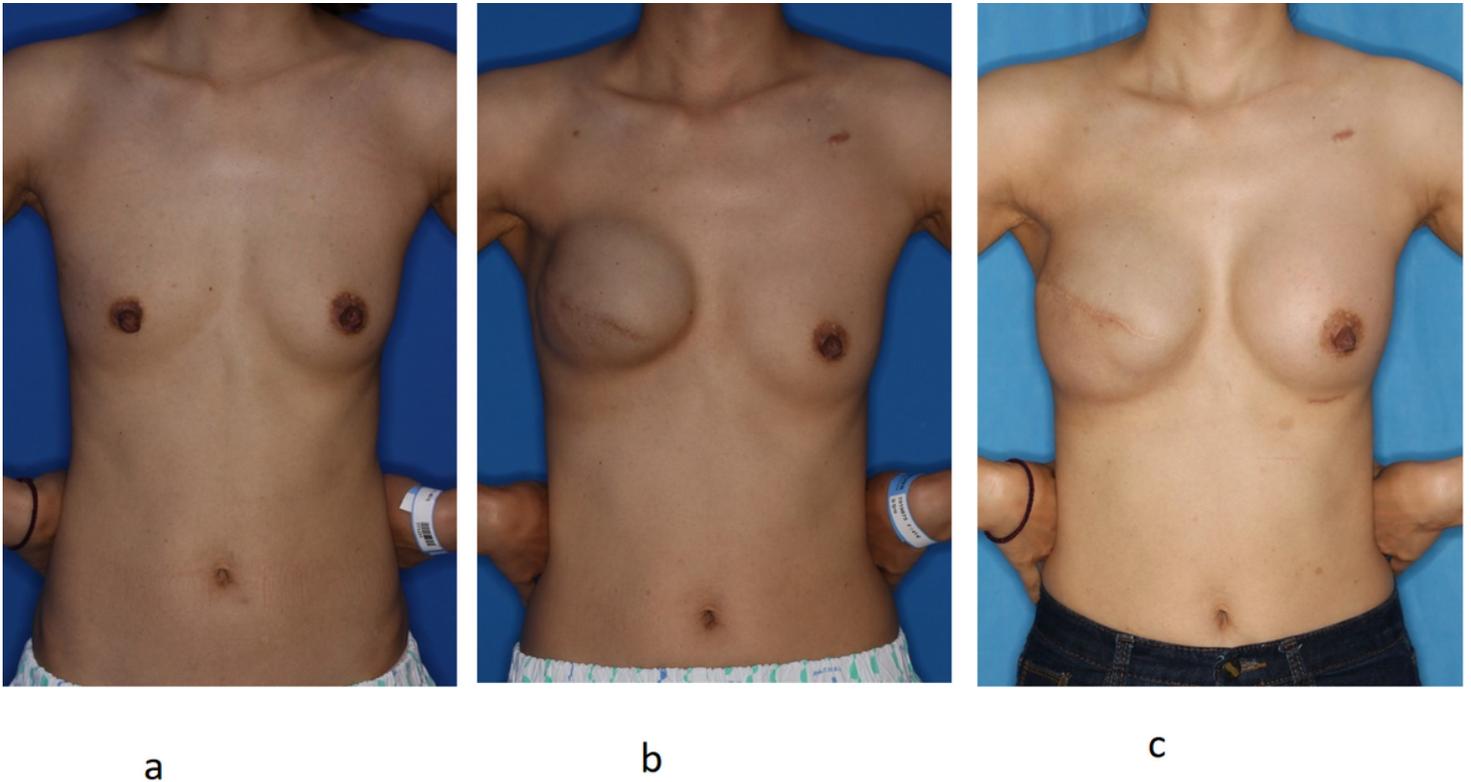


Figure 2

Representative case of two-stage expander-implant breast reconstruction following skin-sparing mastectomy. A 43-year-old woman with right breast cancer, invasive lobular carcinoma, and a history of adjuvant chemotherapy and radiotherapy underwent unilateral skin-sparing mastectomy followed by immediate reconstruction with subpectoral insertion of a 350 cc tissue expander. The weight and volume of the mastectomy specimen were 280 g and 320 cc, respectively, and the initial fill volume was 100 cc. The final fill volume was 350 cc, and the expansion velocity was 250 cc/94 days. At 20 months after the expander surgery (12 months after the completion of radiotherapy), she underwent a second surgery for expander/implant exchange with contralateral augmentation by silicone implant insertion. (A) Preoperative views. (B) Full expanded state. (C) 1 year after surgery.

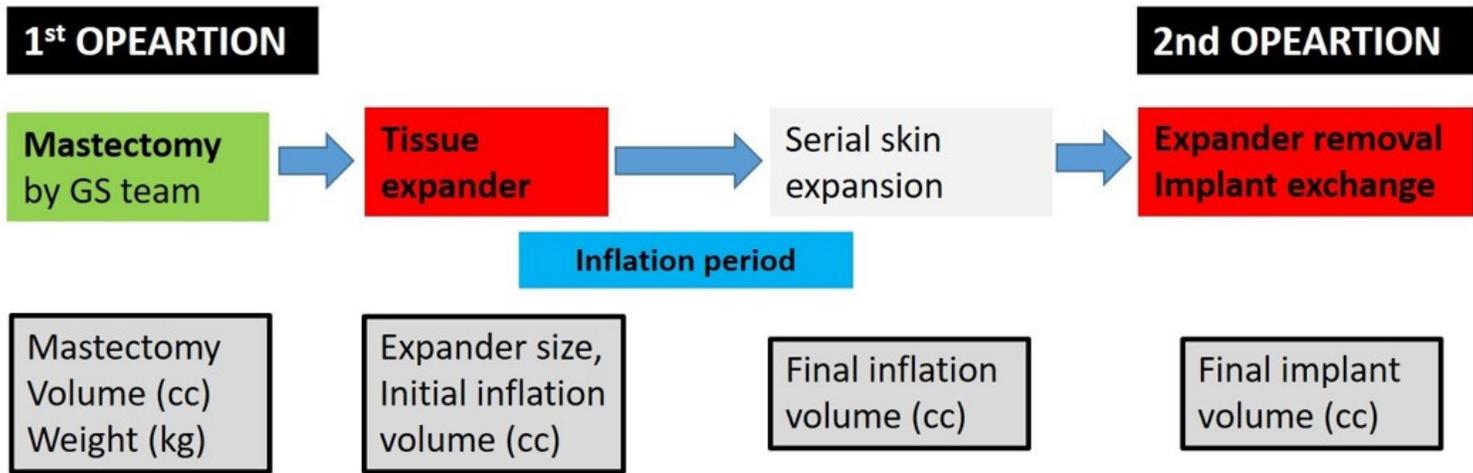


Figure 3

Schematic diagram of the expansion protocol variables in two-stage breast reconstruction

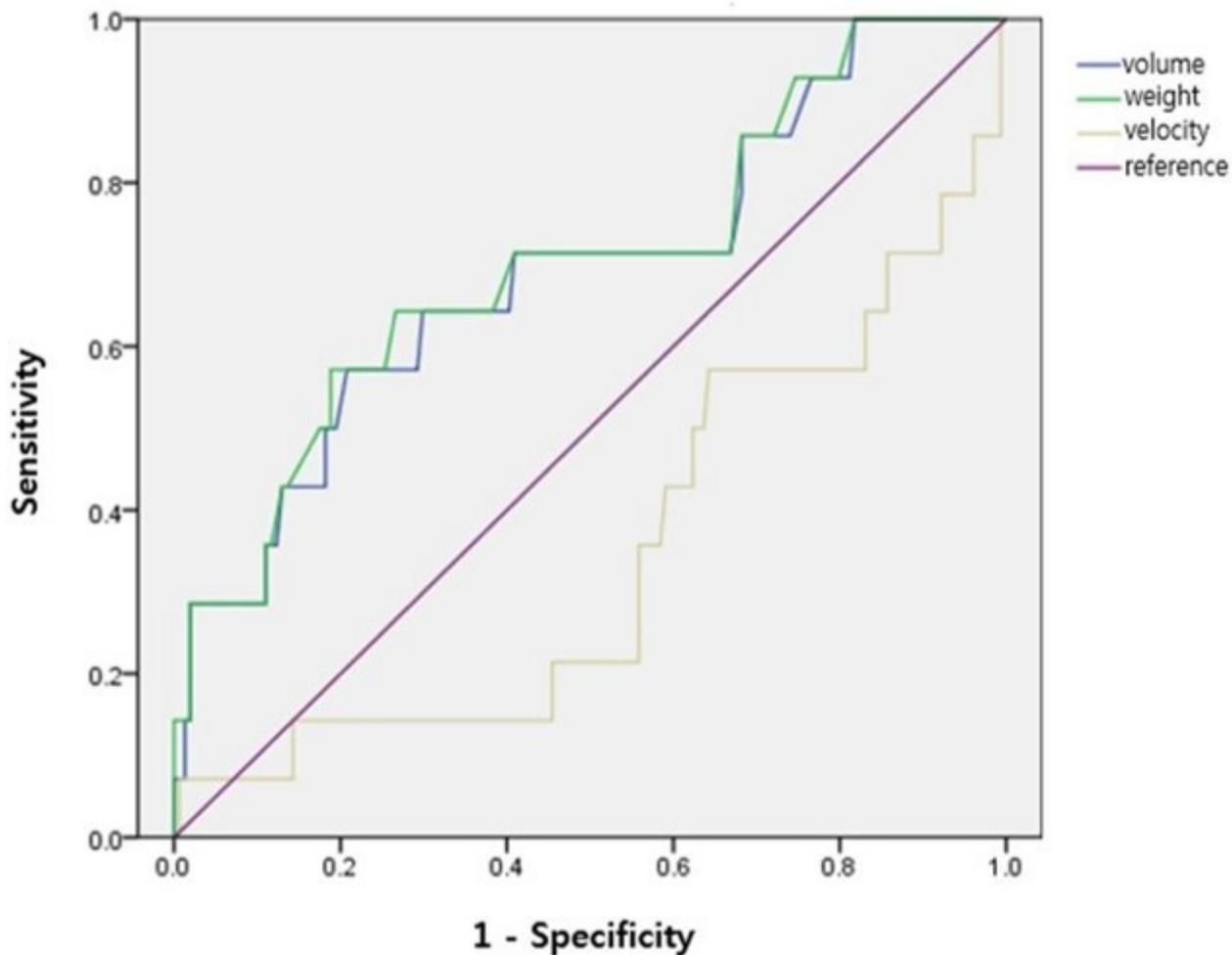


Figure 4

Receiver operating characteristic (ROC) curves for the influencing factors of revision surgery with the breast volume and weight and expansion velocity A breast volume of 505 cc had an area under curve

(AUC) of 0.693; sensitivity, 0.643; and specificity, 0.662,. A breast weight of 695 g had an AUC of 0.702; sensitivity, 0.429; and specificity, 0.818.