Original Article

Comparing outcomes of prepectoral, partial muscle-splitting subpectoral, and dual-plane subpectoral direct-to-implant reconstruction: implant upward migration and the pectoralis muscle

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Background: Although dual-plane subpectoral breast reconstruction has been widely implemented in implant-based breast reconstruction, animation deformities remain an issue. Recent advances in skin flap circulation detection have increased the use of prepectoral reconstruction. A partial muscle-splitting subpectoral plane was introduced to decrease the visibility of the implant edge. However, there is yet to be a direct comparison of these methods for optimal results, including changes in implant position after reconstruction. This study aims to compare the incidence of complications such as rippling, animation deformity, implant upward migration between the dual-plane, the partial muscle splitting subpectoral and the prepectoral reconstruction group. In addition, multivariate analysis was conducted to identify the risk factors of complications.

Methods: We retrospectively investigated 349 patients who underwent unilateral direct-to-implant breast reconstruction from January 2017 to October 2020. Implants were inserted into the dual-plane subpectoral (P2) or partial muscle-splitting subpectoral (P1, the muscle slightly covering the upper edge of the implant) or the prepectoral pocket (P0). Postoperative outcomes and at least 2 years of follow-up complications were compared.

Results: There was no significant difference in rippling (P=0.62) or visible implant edges on the upper pole (P=0.62) among the three groups. In contrast, the P0 group had a lower incidence of seroma (P=0.008), animation deformity (P<0.001), breast pain (P=0.002), and upward implant migration (P0: 1.09%, P1: 4.68%, P2: 38.37%, P<0.001). According to the multivariate analysis, P2 resulted in a greater risk of seroma (odds ratio: 4.223, P=0.002) and implant upward migration (odds ratio: 74.292, P<0.001) than did P0.

Conclusions: P0 and P1 showed better postoperative outcomes than P2. Additionally, P0 had less implant migration than P1. Even though P1 minimally dissects the muscle, the location of the implant may change. Considering that muscle contraction can deteriorate symmetry and aesthetic results, the P0 method may be the most favorable.

Keywords: Breast implants; plastic surgery procedures; pectoralis muscles; foreign body migration

Submitted Feb 13, 2024. Accepted for publication May 29, 2024. Published online Jun 26, 2024.
doi: 10.21037/gs-24-45
View this article at: https://dx.doi.org/10.21037/gs-24-45

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Introduction

Implant-based reconstruction performed on the subpectoral plane was first described by Woods *et al.* (1). This technique could improve hiding of the noticeable edge of the implant and rippling on the upper pole of the breast. However, total submuscular reconstruction restricts the lower pole and leads to indefinite inframammary folds (IMF) and implant migration in the superior direction (2,3). To address these complications, Breuing and Warren reported the use of an acellular dermal matrix (ADM) sling on the inferior pole, which has become a standard technique (4). However, managing animation deformities and defining visible pectoralis major muscle movement remain persistent challenges (5-7). Recently, prepectoral pocket-based implant reconstruction has become more common, owing to the intraoperative confirmation of mastectomy skin perfusion using indocyanine green angiography (8-18). A study introduced a new method in which only the upper part of the pectoralis major muscle was split to cover the implant (partial prepectoral or partial subpectoral plane) to decrease the noticeable implant edge and pectoralis major muscle animation deformity (19).

Highlight box

Key findings

- Post-operatively, 18 to 24 months, the prepectoral group showed significantly lower breast pain rate (3.26%), seroma rate (9.78%) and implant upward migration rate (1.09%).
- According to the multivariate analysis, the implant insertion pocket emerged as significant risk factor for seroma, with an odds ratio (OR) of 4.223 in the comparison between P0 and P2 [P=0.002, 95% confidence interval (CI): 1.723–10.353]. Additionally, age (OR 1.037, 95% CI: 1.001–1.075, P=0.042) and mastectomy specimen weight (OR 1.004, 95% CI: 1.001–1.005, P=0.005) were identified as risk factors for seroma.
- Moreover, multivariate analysis revealed significant risk factors for upward migration of the implant, including implant pocket (P0 *vs.* P2, OR 74.292, 95% CI: 9.383–588.238, P<0.001), age (OR: 1.060, 95% CI: 1.011–1.111, P=0.015), and capsular contracture grade >3 (OR 5.469, 95% CI: 1.133–26.401, P=0.034).

What is known and what is new?

- Prepectoral and partial muscle splitting subpectoral reconstruction show a low incidence of seroma formation, breast pain, animation deformity, and upward migration of the implant than that observed in dual-plane subpectoral reconstruction.
- Among these methods, prepectoral reconstruction resulted in a lower incidence rate of breast pain, seroma, and implant upward migration.

What is the implication, and what should change now?

- Inserting the implant into the prepectoral plane could be the most favorable method for direct-to-implant reconstruction.

Although several studies have been published, there have been no direct comparisons of each method to obtain the best results. Moreover, no study has compared changes in the position of breast implants after reconstruction. Therefore, this study compared groups that underwent implant-based breast reconstruction using dual-plane subpectoral, partial muscle-splitting subpectoral, and prepectoral planes. We present this article in accordance with the STROBE reporting checklist (available at https://gs.amegroups.com/article/view/10.21037/gs-24-45/rc).

Methods

This retrospective study included patients who were diagnosed with breast cancer and who underwent unilateral direct-to-implant (DTI) breast reconstruction at a single center between January 2017 and October 2020. This study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This study was approved by the Ethics Committee of Asan Medical Center affiliated to University of Ulsan, College of Medicine (No. 2023-1358). Individual consent for this analysis was waived due to retrospective nature. The electronic medical records of all patients were reviewed thoroughly, and photographic data were organized by analyzing frontal, lateral, and quarter views of preoperative and postoperative 6-month and postoperative 18- to 24-month photographs.

Patients with a history of breast surgery (47 patients), bilateral DTI (12 patients), implant removal due to complications (9 patients), or conversion to other reconstruction methods (5 patients) were excluded. Patients who underwent bilateral DTI were excluded because we wanted to investigate the positional changes in the reconstructed breast compared with those in the unaffected normal breast. In addition, four patients were excluded from the study because they were lost to follow-up.

Patient demographics, including age, body mass index (BMI), diabetes, hypertension, and smoking history, were investigated. Oncologic data, such as chemotherapy or radiation therapy performed before and after surgery, pathologic stage, type of mastectomy (nipple-areolar-sparing or skin-sparing), and intraoperative data, such as axillary lymph node dissection, implant size, and ADM size, were summarized.

Three plastic surgeons with over 5 years of experience in breast reconstruction (H.H.H., E.K.K., and J.S.E.)

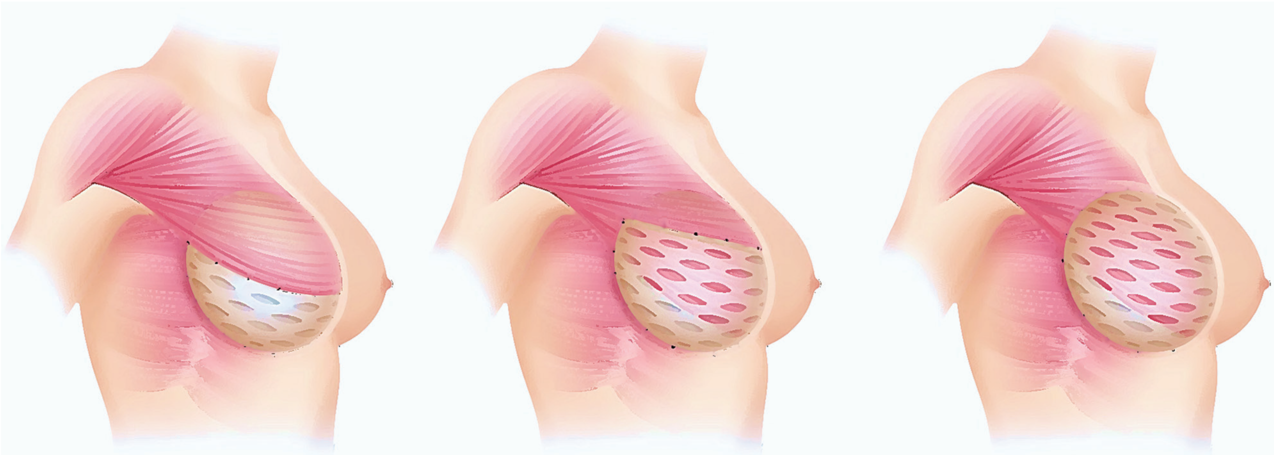

Figure 1 Three methods for direct-to-implant. Dual-plane subpectoral plane (left), partial muscle-splitting subpectoral plane (middle), and prepectoral plane with the full wrapping technique (right).

reconstructed the breasts using the surgical methods described below and presented in *Figure 1*. During the observation period, the trend in the breast-implant pocket plane changed. At the beginning of the study period (January 2017 to December 2018), dual-plane subpectoral breast reconstruction was generally performed, followed by prepectoral and partial muscle-splitting subpectoral breast reconstructions. Therefore, a follow-up period of 2 years after surgery was used for all three groups. Except for this trend, decisions regarding the implant insertion plane were made according to the surgeon's preference.

After mastectomy was performed by three experienced general surgeons with more than 10 years of breast experience (SH Ahn, BH Son, and JW Lee), the circulation of the mastectomy skin flap was evaluated using indocyanine green angiography. When the skin and nipple-areolar complex perfusion were intact, we planned to direct the implantation procedure. IMF repair with Vicryl Plus 2-0 (Ethicon Inc., Somerville, MA, USA) was performed before implant insertion. Interrupted sutures are also used. A temporary implant sizer was inserted to estimate the sizes and locations of the implants.

Prepectoral plane with full wrapping technique (P0)

After determining the implant size, we selected an ADM that encased the entire anterior surface and most of the posterior surface of the silicone implant. The ADM was a square, and the vertices of the square located on the diagonal were approximated and sutured using Vicryl Plus 2-0. The four dog ears created after vertex suturing were trimmed and sutured such that the ADM could completely cover the implant. The wrapped implant was inserted into the prepectoral plane. Fixation sutures to the pectoralis muscle were applied only if the reconstructed breast was too ptotic or had a wide pocket, which could be a risk factor for implant malpositioning. If fixation was inevitable, a one-point suture was made between the superior edge of the ADM and pectoralis major muscle.

Partial muscle splitting in the subpectoral plane (P1)

The upper edge of the temporary silicone sizer was marked with a marking pen. When the mastectomy skin flap was retracted for marking, there is a risk of the implant moving upward. Thus, marking was carefully performed to maintain implant position. The sizer was removed and the horizontal pectoralis major muscle splitting line parallel to the muscle fiber was marked at the upper portion of the muscle to the extent that it slightly covered the upper edge of the sizer. The pectoralis major muscle was partially elevated from the chest wall, and the manually fenestrated ADM was fixed to the edge of the splitting muscle and IMF using Vicryl Plus 2-0. The implant was then inserted, the unnecessary lateral side of the ADM was trimmed, and the ADM was sutured to the lateral chest wall. Finally, the patients were placed in a sitting position to confirm the shape and location of the reconstructed breasts (Video S1).

Subpectoral plane (dual-plane, P2)

This method involves the classic dual-plane subpectoral technique to initiate elevation at the inferior border of the pectoralis major muscle (4). The inferolateral origin of the pectoralis major muscle is elevated from the chest wall. Muscle elevation was performed up to the previously marked edge of the silicone sizer. When the precise pocket was created, the manually fenestrated ADM was sutured with a Vicryl Plus 2-0 suture along the edge of the detached pectoralis muscle and the IMF. The implant was then inserted, the unnecessary lateral side of the ADM was trimmed, and the ADM was sutured to the lateral chest wall. Finally, the patients were placed in a sitting position to confirm the shape and location of the reconstructed breasts.

Cohesive, round-shaped silicone implants with smooth surfaces (Bellagel®; HansBioMed, Seoul, Korea or Mentor® MemoryGel®; Mnetor Worldwide LLC, Irvine, CA, USA) were inserted into all patients and two types of human ADM were used to cover the implants (CGDerm, CGBio Co., Seongnam, Korea and MegaDerm, L&C BIO Inc., Seongnam, Korea).

After skin closure, a wireless surgical brassiere with lateral and superior padding was applied to prevent implant migration. The patient was prohibited from shoulder flexion, extension, and abduction for 2 weeks. Two Jackson-Pratt drains were inserted into the implant pockets. The drains were removed when the amount of fluid was less than 30 cc/day for 2 consecutive days. One week after drain removal, the patient visited the clinic to assess remnant seroma formation.

Definition of complications

Immediate postoperative complications (within 1 month of surgery) such as mastectomy skin necrosis, infection, and hematoma, and data on the average drainage removal period were investigated. All complications were diagnosed by the surgeons. The outcomes included the occurrence of seroma, rippling, visible upper pole implant edge, upward implant migration, animation deformity, capsular contracture, or consistent breast pain. Seroma was confirmed by three surgeons through inspection, palpation, and shifting fluctuation. Aspiration was performed, and a remnant seroma was diagnosed when the amount of aspirated fluid was more than 10 cc. Even if the amount of aspiration was 10 cc, if the breast looked larger or the remnant seroma was still suspicious, the patient revisited the clinic one week later, and aspiration was attempted. Rippling or skin folding was detected through out-patient clinic or photography. A visible upper pole implant edge was reported by patients, who noticed or complained about the edge of the implant. Upward implant migration was identified as upper pole fullness, highly located IMF with breast asymmetry on outpatient clinic records and definite cephalic shifting of the breast maximal projection point observed on the lateral photographic view. Animation deformity was identified as patient-reported significant pectoralis muscle contraction causing discomfort in daily life. Capsular contracture was diagnosed by three surgeons as Baker grade III or IV. Consistent breast pain was diagnosed as the presence of residual breast pain (visual analogue score of six or more) around the breast implant after 2 years of follow-up). Photographs were analyzed by a plastic surgery specialist (K.M.) and a plastic surgery resident (J.C.M.). They analyzed the visible upper pole implant edge, rippling, and upward implant migration categories by comparing the results preoperative, 6 months postoperative, and 18–24 months postoperative. Even with IMF repair, achieving perfect symmetry of the IMF and complete balance of the breast mound may not be possible. Therefore, particular attention was paid to comparing the positions of the breast implants at 6 months and 2 years postoperatively in the plain and lateral views to determine any differences. The instances for which differences were diagnosed by both observers were defined as rippling, visible upper pole implant edges, and upward migration. Animation deformities and capsular contractures were not investigated using photography. One of the photo analysts (K.M.) assisted in some of the breast reconstruction cases; however, the doctor did not manipulate the implant nor ADM. The two analysts were blinded to the patient information, such as the patient's age and implant pocket plane.

Statistical analysis

Analysis of variance was performed for continuous variables to compare the three groups. The chi-squared or Fisher's exact tests were used for categorical variables. Multivariate linear regression analysis with backward elimination of continuous variables and multivariate logistic regression analysis with backward elimination of categorical variables were performed to obtain the odds ratios (ORs) of complications showing significance. When multivariate analysis was conducted, variables with a P value less than 0.1 were considered independent variables. All the statistical analyses were performed using IBM SPSS software (IBM SPSS Statistics for Windows, Version 26.0., IMB Corp., Armonk, NY, USA).

Results

A total of 349 patients underwent unilateral DTI, and ADM was used in all patients. The P0, P1, and P2 groups comprised 92, 169, and 86 patients, respectively. A significant difference in BMI was observed between the P0, P1, and P2 groups (22.67±2.87 *vs.* 22.58±2.63 *vs.* 21.54±2.55 kg/m^2, P=0.009). None of the patients underwent a revision procedure for aesthetic purposes, such as fat grafting.

The mastectomy specimen weight was 331.90±156.47 g in the P0 group and 323.01±135.87 g in the P1 group. The P2 group was significantly lighter at 276.12±116.60 g (P=0.01). The inserted implant volume was 279.62±96.47 mL in the P0 group, 286.73±93.73 mL in the P1 group, and 251.80±84.77 in the P2 groups (P=0.02). In contrast, the area of the ADM used during surgery was the widest in the P0 group (142.39±32.48 cm^2), followed by the P1 group (122.73±24.35 cm^2) and the P2 group (94.52±15.15 cm^2) (P<0.001). No other significant differences were observed among the three groups, including adjuvant chemotherapy/radiotherapy, mastectomy skin preservation type, or axillary lymph node dissection (*Table 1*).

In the case of complications, none of the patients in the P0 and P1 groups had animation deformities; however, 5 patients in the P2 group (5.81%) (P<0.001) had deformities. Moreover, 3 patients (3.26%) in the P0 group and 6 patients (3.51%) in the P1 group reported persistent breast pain at two years postoperatively, while 12 patients in the P2 group (13.95%) reported pain (P=0.002).

The mean period of drain removal after reconstruction was the shortest in the P0 group at 14.98±3.95 days, followed by 16.01±4.10 days in the P1 group and 16.97±4.77 days in the P2 group (P=0.008). In addition, episodes of seroma aspiration during the follow-up period were observed in nine patients (9.78%) in the P0 group, 20 (11.83%) in the P1 group, and 21 patients (24.42%) in the P2 group (P=0.008).

Rippling of the reconstructed breast was observed in 22 patients (23.91%) in the P0 group, 42 patients (24.26%) in the P1 group, and 26 patients (30.23%) in the P2 group, with no significant difference (P=0.53). In addition, no significant difference was observed in the visible implant edge of the upper pole (P0: 2.17%, P1: 2.92%, P2: 4.65%, P=0.62). On the other hand, significant differences in upward migration of the implant were observed: 1 patient (1.09%) in the P0 group, 8 patients in the P1 group (4.68%), and 33 patients (38.37%) in the P2 group (P<0.001, *Table 2*, *Figures 2-4*).

Multivariate analysis was performed on the drain removal period, seroma, and upward implant migration, which differed significantly between the groups. The factors affecting the drain maintenance period were the implant pocket [beta 0.248, P<0.001, variance inflation factor (VIF) 1.050], age (beta 0.199, P<0.001, VIF 1.070), and mastectomy specimen weight (beta 0.337, P=0.001, VIF 1.479, *Table 3*). In the case of seroma, the implant insertion pocket was a significant risk factor, with an OR of 4.223 measured in the P0 and P2 comparisons [P=0.002, 95% confidence interval (CI): 1.723–10.353]. Additionally, age (OR 1.037, 95% CI: 1.001–1.075, P=0.04) and mastectomy specimen weight (OR 1.004, 95% CI: 1.001 to 1.005, P=0.005) were risk factors (*Table 4*). Furthermore, the significant risk factors for upward migration of the implant were implant pocket (P0 *vs.* P2, OR 74.292, 95% CI: 9.383–588.238, P<0.001) age (OR 1.060; 95% CI: 1.011–1.111; P=0.02), and capsular contracture grade >3 (OR 5.469, 95% CI: 1.133–26.401, P=0.03; *Table 5*).

Discussion

Unsatisfactory breast reconstruction using implants after total mastectomy often results from implant-related short-term postoperative complications such as infection and bleeding, along with the occurrence of long-term complications such as capsular contracture, animation deformity, and abnormal implant position. ADM and prepectoral breast insertion have been introduced to improve capsular contracture and animation deformities, and several studies have validated their effectiveness (3,20,21).

Implant-based breast reconstruction using a prepectoral pocket has several advantages; however, as the round implant is placed right under the relatively thin mastectomy skin flap, fullness of the upper pole and a visible implant edge on the upper side are common, and rippling of the upper pole may occur (22-24). Pittman *et al.* introduced the partial prepectoral (partial subpectoral) method to address this issue (19), which showed no incidence of implant rippling or animation deformities. However, they did not directly compare the prepectoral and subpectoral planes.

Several studies have compared the results of implant-based breast reconstruction using the prepectoral or dual-plane subpectoral planes (15,16,18,25-34). Chandarana *et al.* conducted a comparative study on 130 breasts using BRAXON® in the prepectoral group and ADM in the dual-plane subpectoral group (25). No differences were observed in complications other than greater capsular contractures

Table 1 Baseline characteristics

Variables	P0 (n=92)	P1 (n=171)	P2 (n=86)	P value	Multiple comparison's P value with Bonferroni correction		
					P0 *vs.* P1	P0 *vs.* P2	P1 *vs.* P2
Age (years)	45.92±9.81	45.92±9.09	43.40±7.95	0.08			
BMI (kg/m^2)	22.67±2.87	22.58±2.63	21.54±2.55	0.009*	>0.99	0.02	0.02
Diabetes mellitus	3 (3.26)	5 (2.92)	1 (1.16)	0.63			
Hypertension	7 (7.61)	11 (6.43)	3 (3.49)	0.49			
Smoking	3 (3.26)	13 (7.60)	2 (2.33)	0.12			
Neoadjuvant chemotherapy	21 (22.83)	41 (23.98)	25 (29.07)	0.58			
Adjuvant chemotherapy	30 (32.61)	38 (22.22)	17 (19.77)	0.10			
Adjuvant radiotherapy	19 (20.65)	30 (17.54)	7 (8.14)	0.057			
Hormonal therapy	61 (66.30)	119 (69.59)	54 (62.79)	0.54			
T stage (per patient)							
Tis	23 (25.00)	44 (25.73)	3 (3.49)	0.18			
T1	42 (45.65)	63 (36.84)	46 (53.49)				
T2	21 (22.83)	55 (32.16)	19 (22.09)				
T3	6 (6.52)	9 (5.26)	2 (2.33)				
N stage (per patient)							
N0	62 (67.39)	126 (73.68)	69 (80.23)	0.49			
N1	23 (25.00)	37 (21.64)	15 (17.44)				
N2	4 (4.35)	6 (3.51)	1 (1.16)				
N3	3 (3.26)	2 (1.17)	1 (1.16)				
NSM	73 (79.35)	118 (69.01)	60 (69.77)	0.18			
SSM	19 (20.65)	53 (30.99)	26 (30.23)				
Mastectomy specimen (g)	331.90±156.47	323.01±135.87	276.12±116.60	0.01*	>0.99	0.02	0.03
Axillary node dissection	33 (35.87)	49 (28.65)	24 (27.91)	0.41			
Implant size (cc)	279.62±96.47	286.73±93.73	251.80±84.77	0.02*	>0.99	0.14	0.01
ADM size (cm^2)	142.39±32.48	122.73±24.35	94.52±15.15	<0.001*	<0.001	<0.001	<0.001
Operation time (min)	60.60±24.00	82.98±25.39	111.03±37.09	<0.001*	<0.001	<0.001	<0.001

Data are presented as mean ± standard deviation or number (%). P0, prepectoral; P1, partial muscle splitting subpectoral; P2, dual-plane subpectoral. Continuous variables: analysis of variance; categorical variables: Chi-square test or Fisher's exact test; Post-hoc test, variables of P<0.05. *, P<0.05. BMI, body mass index; NSM, nipple sparing mastectomy; SSM, skin sparing mastectomy; ADM, acellular dermal matrix.

in the dual subpectoral plane. Yang *et al.* conducted a study targeting a mixed group of patients with DTI and two-stage disease, and reported that the prepectoral plane group had more seromas and rippling than the dual-plane subpectoral group (34). Plachinski *et al.* compared 183 breasts that included ADM (31). They reported significant animation deformity in the dual-plane subpectoral group; however, no differences in capsular contracture or drain removal time were observed.

Previous studies have limitations, such as the lack of

Table 2 Outcome and complications

Variables	P0 (n=92)	P1 (n=171)	P2 (n=86)	P value	Multiple comparison's P value with Bonferroni correction		
					P0 *vs.* P1	P0 *vs.* P2	P1 *vs.* P2
Significant animation deformity	0	0	5 (5.81)	<0.001*	–	<0.001	<0.001
Breast pain	3 (3.26)	6 (3.51)	12 (13.95)	0.002*	>0.99	<0.001	<0.001
Capsular contracture	4 (4.35)	5 (2.92)	5 (5.81)	0.53			
Drainage removal (days)	14.98±3.95	16.01±4.10	16.97±4.77	0.008*	0.18	0.006	0.27
Seroma	9 (9.78)	20 (11.70)	21 (24.42)	0.008*	0.60	0.009	0.01
Rippling	22 (23.91)	42 (24.56)	26 (30.23)	0.53			
Noticeable upper pole implant edge	2 (2.17)	5 (2.92)	4 (4.65)	0.62			
Implant upward migration	1 (1.09)	8 (4.68)	33 (38.37)	<0.001*	<0.001	<0.001	<0.001

Data are presented as mean ± standard deviation or number (%). P0, prepectoral; P1, partial muscle splitting subpectoral; P2, dual-plane subpectoral. Continuous variables: analysis of variance; categorical variables: Chi-square test or Fisher's exact test. *, P<0.05.

Figure 2 A 46-year-old female patient received direct-to-implant breast reconstruction on her left breast and contralateral lumpectomy (left). A 215 cc-sized silicone implant was inserted on the dual-plane subpectoral space. She did not undergo radiation therapy. Upward migration was observed in the postoperative 6 months photograph (middle) and was more prominently observed in the postoperative 21 months photograph (right).

standardization of variables in comparison groups, such as the reconstruction stage, use of ADM, or mastectomy specimen weight. Moreover, there has been no direct comparative analysis of whether the partial muscle-splitting subpectoral group has advantages over the prepectoral and dual-plane subpectoral groups. Thus, this study aimed to identify the advantages and disadvantages of these three surgeries by comparing the results of patients who underwent unilateral prepectoral, partial muscle splitting subpectoral, and dual-plane subpectoral DTI surgeries and were followed up for 2 years.

Köpke *et al.* noted that elderly patients with large breast volumes had an increased risk of seroma formation after mastectomy (29). In addition, Ozturk *et al.* reported a seroma or prolonged drain after breast reconstruction with a tissue expander in patients with larger breasts (30). Not only the size of the breast but also the dimensions of the ADM can be risk factors for seroma formation. When ADM ingrowth into a patient's tissue is insufficient, it may produce fluid that can inhibit wound healing and create additional body fluid (30). Because prepectoral and partial muscle splitting subpectoral reconstruction use a larger surface area of ADM, it can cause more seroma.

In this study, the weight of the mastectomy specimen

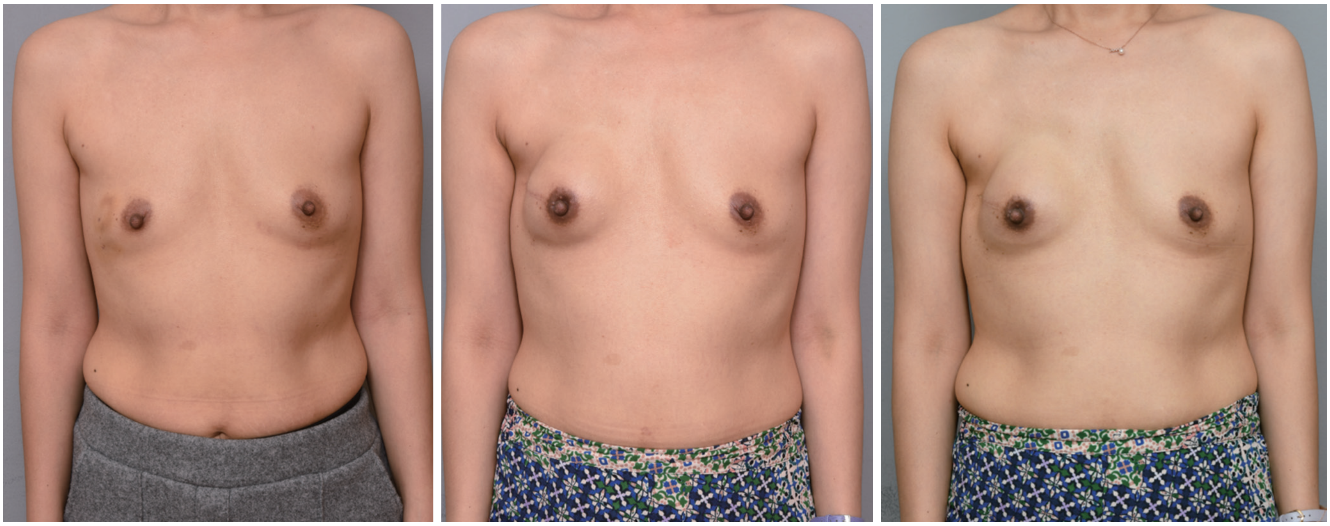

Figure 3 A 47-year-old female patient received a 150 cc-sized silicone implant in her right breast (left). A partial muscle-splitting subpectoral plane was used as an implant pocket. She did not undergo radiation therapy. There was no severe change of implant position at postoperative 6 months (middle) and 18 months (right).

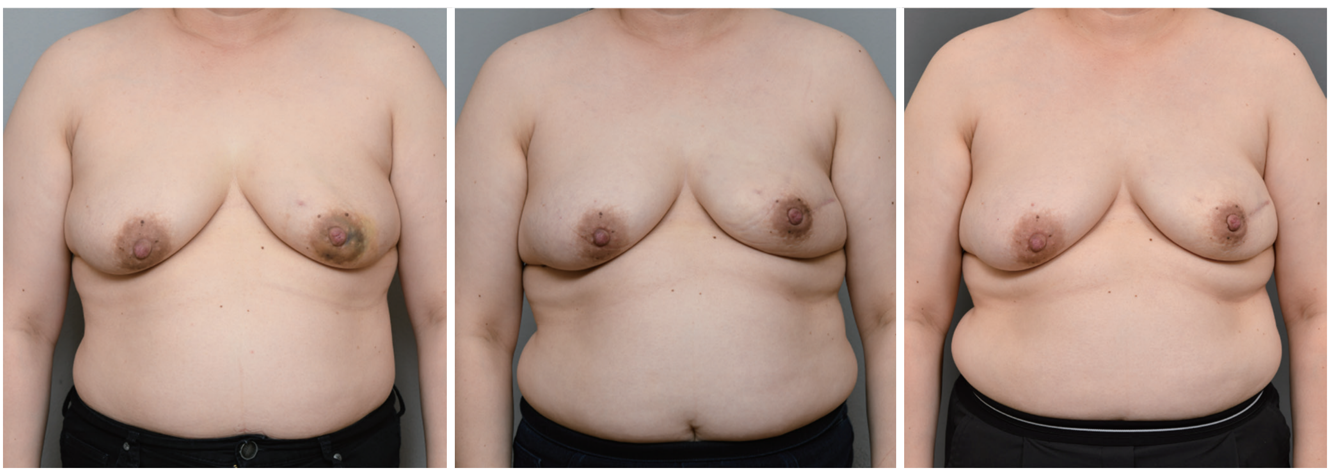

Figure 4 A 38-year-old female patient underwent a direct-to-implant operation on her left breast (left). A 405 cc-sized silicone implant was inserted on the prepectoral pocket with ADM full wrapping. She did not undergo radiation therapy. On postoperative 1- and 2-year photographs, no change of implant was observed (middle and right). ADM, acellular dermal matrix.

was the lowest and the size of the ADM was the smallest in the dual-plane subpectoral group. However, the period of drainage removal and the occurrence of seroma aspiration were longer than those in the prepectoral and partial muscle-splitting subpectoral groups. These results indicated that ADM may not be the most critical factor for postoperative seroma formation. Rather, repeated muscle contraction might interfere with the vascularization and integration of the ADM into the mastectomy skin flap. Consequently, the amount of drainage can be increased.

Moreover, there were no differences among the three groups in terms of rippling, severe capsular contracture, or noticeable implant edges on the upper pole of the breast. These findings contradict those of previous studies that reported less rippling during dual-plane subpectoral reconstruction and a less noticeable implant edge during partial muscle-splitting subpectoral reconstruction (19,31).

In this study, the average BMI was 22 kg/m^2, and the

Table 3 Multivariable linear regression analysis for drain removal period

Variables	Beta	*t*	P value	VIF
P0 *vs.* P1 *vs.* P2	0.248	5.164	<0.001*	1.050
Age	0.199	4.097	<0.001*	1.070
BMI	0.098	1.676	0.10	1.553
Mastectomy specimen weight	0.337	5.914	<0.001*	1.479
Adjuvant chemotherapy	–0.052	9.067	0.29	1.065
Adjuvant radiotherapy	0.054	1.990	0.26	1.066
Constant		3.569	0.07	

*, P<0.05. Independent variables for the analysis: P0 *vs.* P1 *vs.* P2, age, BMI, adjuvant chemotherapy, adjuvant radiotherapy, mastectomy specimen weight. R=0.498, adjusted R^2 =0.235. P0, prepectoral; P1, partial muscle splitting subpectoral; P2, dual-plane subpectoral. BMI, body mass index; Beta, standardized coefficients; VIF, variance inflation factor.

Table 4 Multivariable logistic regression analysis for seroma

Variables	OR	95% CI	P value
P0 *vs.* P1 *vs.* P2			0.001*
P0 *vs.* P1	1.293	0.554–3.017	0.55
P1 *vs.* P2	3.265	1.588–6.715	0.001*
P0 *vs.* P2	4.223	1.723–10.353	0.002*
Age	1.037	1.001–1.075	0.04*
Mastectomy specimen weight	1.004	1.001–1.005	0.005*

*, P<0.05. Independent variables for the analysis, P0 *vs.* P1 *vs.* P2, age, BMI, adjuvant chemotherapy, adjuvant radiotherapy, mastectomy specimen weight. P0, prepectoral; P1, partial muscle splitting subpectoral; P2, dual-plane subpectoral. OR, odd ratio; CI, confidence interval; BMI, body mass index.

Table 5 Multivariable logistic regression analysis for implant upward migration

Variables	OR	95% CI	P value
P0 *vs.* P1 *vs.* P2			<0.001*
P0 *vs.* P1	4.479	0.540–37.134	0.17
P1 *vs.* P2	16.586	6.715–40.966	<0.001*
P0 *vs.* P2	74.292	9.383–588.238	<0.001*
Age	1.060	1.011–1.111	0.02*
Adjuvant chemotherapy	2.493	0.832–7.471	0.10
Capsular contracture grade >3	5.469	1.133–26.401	0.03

*, P<0.05. Independent variables for the analysis: P0 *vs.* P1 *vs.* P2, age, BMI, adjuvant chemotherapy, adjuvant radiotherapy, mastectomy specimen weight and capsular contracture grade >3. P0, prepectoral; P1, partial muscle splitting subpectoral; P2, dual-plane subpectoral. OR, odd ratio; CI, confidence interval; BMI, body mass index.

average implant size was approximately 280 cc, indicating a high chance of rippling after breast reconstruction due to the thin skin flap after mastectomy. However, the mastectomy skin flap thickness was not measured in any of the patients in this study. Therefore, the conclusion that the dual-plane subpectoral plane does not help reduce rippling should be avoided, and further research is necessary to clarify this issue. Further studies are needed to determine the role of elevated pectoralis major muscles in preventing rippling.

Ensuring symmetry of the breast when performing unilateral breast reconstruction is important and is largely attributed to the settled position of the implant. Sobti *et al.* compared prepectoral and subpectoral groups that received postmastectomy radiotherapy and assumed that radiation-induced fibrosis of the pectoralis major muscle could be the main contributor to breast asymmetry and capsular contracture (32). Since most studies included bilateral breast reconstruction, changes in the position of the implant after surgery could not be confirmed. Moreover, to the best of our knowledge, no study has compared changes in the position of the reconstructed breast without radiotherapy. This study observed significantly more upward migration of the implant in the dual-plane subpectoral group. When the ADM is fixed with threads at the lower border of the pectoralis muscle and IMF to cover the lower pole of the implant, the pectoralis major muscle pulls the ADM upward over time, resulting in an elevated position of the implant. In addition, the Bonferroni posthoc analysis between the prepectoral group and partial muscle-splitting subpectoral group revealed that the upward migration of the implant was significantly greater in the partial-splitting subpectoral group than in the prepectoral group. These findings suggest that even if a small amount of muscle is elevated, upward migration is possible during muscle contraction.

This study has several limitations. First, although the study was conducted on 349 patients over a 4-year period, there were fewer than 100 prepectoral and dual-plane subpectoral patients. Second, the demographics of the patients were not uniform due to the retrospective nature of the study; therefore, a propensity score matching study would be more sensible. Finally, the upward migration of breast implants was not quantitatively measured. Because there are differences between severe and minimal migration, performing a quantitative analysis will allow for a more precise analysis of the effect of the pectoralis muscle on the position of the implant.

Additionally, none of the patients underwent ancillary procedures, such as fat grafting or implant change, probably because of the national insurance system, which provides benefits only for breast reconstruction after total mastectomy and not for secondary procedures. Moreover, because the average BMI was not high and the measured breast size was small owing to the characteristics of the Asian population, additional research including diverse ethnicities and body shapes is necessary.

Conclusions

Prepectoral and partial muscle-splitting subpectoral reconstruction are associated with a lower incidence of seroma formation, breast pain, animation deformity, and upward migration of the implant than dual-plane subpectoral reconstruction. Furthermore, prepectoral reconstruction showed a lower incidence of upward implant migration than did partial muscle-splitting subpectoral reconstruction. Partial muscle-splitting subpectoral reconstruction, which minimally dissects the muscle, can also affect the implant location. Considering that breast reconstruction using muscles can deteriorate the symmetry and aesthetic results of the breast during long-term follow-up due to muscle contraction, insertion of the implant into the prepectoral plane could be the most favorable method for direct implant reconstruction.

Acknowledgments

We would like to thank Editage (www.editage.co.kr) for editing and reviewing this manuscript for English language.
Funding: None.

Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://gs.amegroups.com/article/view/10.21037/gs-24-45/rc

Data Sharing Statement: Available at https://gs.amegroups.com/article/view/10.21037/gs-24-45/dss

Peer Review File: Available at https://gs.amegroups.com/article/view/10.21037/gs-24-45/prf

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://gs.amegroups.com/article/view/10.21037/gs-24-45/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. This study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This study was approved by the Ethics Committee of Asan Medical Center affiliated to University of Ulsan, College of Medicine (No. 2023-1358). Individual consent for this analysis was waived due to retrospective nature.

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Cite this article as: Min K, Min JC, Han HH, Kim EK, Eom JS. Comparing outcomes of prepectoral, partial muscle-splitting subpectoral, and dual-plane subpectoral direct-to-implant reconstruction: implant upward migration and the pectoralis muscle. Gland Surg 2024;13(6):852-863. doi: 10.21037/gs-24-45