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ORIGINAL ARTICLE

Breast Reconstruction: Complication Rate and Tissue Expander Type

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Abstract
Background Limited literature exists regarding complication rates among women undergoing breast reconstruction and the association of these rates with tissue expander types (anatomic, round and Becker).
Methods A historical cohort study investigated all breast reconstructions performed at Hadassah Medical Center for 140 consecutive women. Analyses were performed using both logistic and Poisson regression multivariate methods.
Results At least one major complication occurred in each of the following groups: anatomic (41%), round (20%), and Becker (11.7%) ($p = 0.015$). Women reconstructed with anatomic expanders were at increased risk for at least one complication (odds ratio [OR], 3.96; 95% confidence interval [CI], 1.18–13.3; $p = 0.026$) and an average increase of 331% (95% CI, 102–817%; $p = 0.0002$) in the number of major complications.
Conclusion The results of this study suggest that integrated-valve expanders are associated with more complications than the distant inflation port. The benefits of an anatomic shape may perhaps be better exploited using devices with a distant port.

Keywords Breast reconstruction · Complication · Tissue expanders

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Breast reconstruction after mastectomy is a common approach to the management of breast cancer. Tissue expansion followed by insertion of a permanent implant or insertion of an expander-implant (e.g., Becker expander) during a single procedure often is used.

Several years ago, the biodimensional integrated-valve ("anatomic") expander was introduced. It is designed as a teardrop, achieving selective expansion in the lower pole, thus providing the reconstructed breast a more natural look and differing from round and Becker expanders.

Another unique feature is the inflation port, embedded in the anatomic expander's body, compared with the round and Becker expanders. The inflation port is distant from the expander and connected by a thin tubing system. The anatomic expander's embedded port contains a rigid ring on its superoanterior surface that increasingly presses against the mastectomy skin flap as the expander inflates, whereas the round and Becker expanders have a uniform, relatively soft, surface.

In our department, we have interchangeably used all three types of expanders (round, anatomic, and Becker) according to the preferences of the operating surgeons and patient demand. We reviewed our experience using these prostheses with 140 consecutive patients. This study aimed to compare complication rates in all three groups and identify risk factors associated with each of these expanders.

Methods

This study enrolled all women who underwent breast reconstruction using tissue expanders (TE) from 1 January 2000 to 1 April 2005 at Hadassah, a 950-bed academic medical center. Files were searched in archives according to relevant International Classification of Diseases (ICD)-9

codes identifying all breast procedures and cross-referenced with the implant records kept for insurance purposes. All tissue expanders were manufactured by the Mentor Corporation (Santa Barbara, CA, USA).

All patient files were examined for the patients who underwent breast reconstruction. This study was approved by the institutional review board in accordance with the ethical requirements stated in the Helsinki committee document.

The decision concerning which expander to use in the operative procedure was according to the main surgeon's preferences. Most often, small and nonptotic breasts were programmed to be reconstructed in a single stage using a Becker expander-implant. For larger and pendulous breasts, a two-stage reconstruction was planned, allowing revision of the reconstruction and contralateral breast surgical adaptations. Is such cases, round and anatomic expanders were used interchangeably. Strict adherence to these considerations is not required of the surgeons in our department.

Insertion of the expander was performed through the mastectomy scar. The expander was placed in a complete submuscular pocket, which was closed in layers, leaving a drain in the expander pocket. All the operations were preformed under the same sterility protocol in the operating theaters of both Hadassah Medical Center campuses (Ein Kerem and Mount Scopus). When the main operating surgeon was a resident, the operations were supervised by a senior surgeon.

The patients were followed up by the main surgeon. Inflation began at least 2 weeks after discharge, usually when the surgical wound had healed and no signs of local inflammation were evident.

The following information was extracted from the patient medical records: the patient's demographic and general health information (age, ethnicity, weight, smoking status, comorbidities, and medications), data concerning breast cancer illness and surgery (unilateral or bilateral surgery, diseased breast vs prophylactic mastectomy, immediate or delayed reconstruction, and previous chemotherapy or radiotherapy), details of the surgical procedure (tissue expander type and volume, use of drains and perioperative antibiotics, surgery length, identity and seniority of surgeons, and whether any difficulties were encountered during the procedure involving the quality of skin and muscle flaps, bleeding, insufficient muscle coverage), records of the hospitalization period (length of stay in the surgical or plastic surgery ward, antibiotic treatment, and any in-house complications), chemotherapy or radiotherapy, and number of inflations as well as their duration and complications noted during the inflation period preceding permanent implantation or sufficient Becker implant inflation.

The main study outcome was the occurrence of a major complication. This outcome was appraised both by measuring risks of experiencing at least one outcome and by measuring the count of major complications per case. Major complications included any event requiring hospitalization after surgery such as parenteral antibiotic treatment, tissue expander puncture, tissue expander removal, surgical wound revision, or drainage. A similar assessment was performed for minor complications, defined as local seroma, hematoma, oral antibiotic treatment, delayed wound closure, pain, and local pressure sensation.

We investigated potential variables influencing the postulated association between tissue expander type and complications. Some women underwent more than one procedure per breast or procedures on both breasts. Whereas some of the variables are patient unique (age, weight, smoking status), other characteristics are more breast or procedure dependant (regional radiation and duration of surgery, respectively). Therefore, appropriate statistical analyses were performed per patient, breast, or procedure. Therefore, in stratifying the analyses as aforementioned, we attempted to overcome violation of basic assumptions of independence of subjects.

Statistical Analysis

The baseline characteristics of the three subgroups (anatomic, round, and Becker) were compared using one-way analysis of variance (ANOVA) and the Kruskal-Wallis test for the numeric variables. The chi-square test was used for the categorical variables. The p values for the comparison among the three subgroups were reported. A multivariate approach was used to examine the overall multivariate effect of the predictors (the independent variables) on the outcome variables. To examine whether the treatment type affects the occurrence of at least one complication while controlling for the confounding effects of all other independent variables, the multivariate logistic regression model was used [1]. Using this model allows us to estimate the odds ratio (OR) for each of the independent variables, the p value of each, and the associated 95% confidence interval (CI).

To examine whether the treatment type affects the count of complications, while controlling for the confounding effects of all other independent variables, the multivariate Poisson regression model was used [2, 3]. Because in our study the dependent variable is the count of complications and this count is related to a number of factors, the Poisson process is the underlying mechanism being modeled. Using this model allows us to estimate the relative risk (RR) for each of the independent variables, the p value of each, and the associated 95% CI.

The RR of each independent variable measures the percentage of change in the count of complications due to the effect of this variable. We used the quasi-likelihood Poisson model to overcome the overdispersion. All analyses were performed using SPSS version 13.0.1 software (SPSS Inc., Chicago, IL, USA) and Splus version 6.1 software (Copyright 1988, 2002 by the Insightful Corp. Seattle, WA, USA).

Results

Our study included 140 women, 170 breasts (30 women had bilateral breast reconstruction), and 178 procedures for tissue expander insertions. In 148 cases, the mastectomy was performed after carcinoma diagnosis, compared with 30 cases managed prophylactically. Whereas 136 women had immediate reconstruction, 42 underwent late reconstruction. Six women were excluded from the study because their medical records were not available.

Table 1 presents the study variables stratified by tissue expander type per woman, breast, and procedure. The anatomic tissue expander group had a higher proportion of women who underwent chemotherapy and radiation before tissue expander implantation and a higher proportion of women who had both breasts reconstructed. Additionally, these women had a higher rate of late reconstructions. Anatomic implants were used more often when the main surgeon was a resident.

Table 2 presents the crude complication rates. Overall, 24 women (18%) experienced at least one major complication, and 69 women (52%) experienced at least one minor complication. Analyses per breast and procedure provided similar results. Examination found that for their first procedure, 11 women (64%) had anatomic, 32 (80%) had round, and 72 (94%) had Becker tissue expanders, achieving either a permanent implant or appropriate breast volume ($p = 0.004$). Overall, one woman with anatomic (6%), three women with round (7.5%), and two women with Becker (2.6%) tissue expanders did not achieve complete reconstruction ($p = 0.37$). Table 3 further depicts the specific complication rates for major and minor complications.

Because the complication rates were similar for both the round and Becker groups, and consistently different from the rate for the anatomic group, the RRs were combined for the two groups. The crude RRs for at least one major complication with an anatomic expander compared were

Table 1 Patient characteristics stratified per woman, breast, and procedure

Per woman	Anatomic ($n = 17$) n (%)	Round ($n = 40$) n (%)	Becker ($n = 77$) n (%)	p Value
Bilateral reconstruction	6 (35)	12 (30)	11 (14.3)	0.0475
Previous chemotherapy	10 (59)	8 (22)	24 (34)	0.02
Chemotherapy after first surgery	3 (18)	15 (38)	22 (29)	0.3
Comorbidities	7 (41)	13 (32.5)	21 (29)	0.5
Smoker status	1 (6.3)	10 (33)	13 (19.4)	0.2
Mean age	46 ± 11	44 ± 8	45 ± 9	0.8
Mean TE volume	443 ± 107	530 ± 125	370 ± 113	<0.001
Mean weight	69 ± 9	66 ± 12	62 ± 9	0.01
Per breast	**Anatomic ($n = 23$)**	**Round ($n = 52$)**	**Becker ($n = 88$)**	
Previous radiation	7 (30)	0	11 (12.5)	0.002
Right breast procedure	10 (43)	28 (54)	41 (47)	0.6
Radiation during follow-up	2 (9)	8 (15)	12 (14)	0.7
Prophylactic procedure	4 (18)	12 (23)	13 (15)	0.46
Late reconstruction	12 (52)	7 (13)	19 (22)	0.001
Per procedure	**Anatomic ($n = 24$)**	**Round ($n = 55$)**	**Becker ($n = 90$)**	
Resident surgeon	12 (50)	10 (18)	25 (28)	0.015
Mean duration of operation (h)	2.5 ± 1.1	3.3 ± 1.2	3.5 ± 5.3	0.57
Mean duration of inflation (days)	110 ± 109	68 ± 57	65 ± 68	0.036
Mean inflation volume (CC)	67 ± 16	86 ± 24	76 ± 19	0.001
Mean CC inflated in surgery	60 ± 38	93 ± 50	41 ± 26	<0.001

TE, tissue expander; CC, cubic centimeter

Table 2 Complications stratified per woman, breast, and procedure

Per woman	Anatomic ($n = 17$) n (%)	Round ($n = 40$) n (%)	Becker ($n = 77$) n (%)	p Value
At least 1 major complication	7 (41)	8 (20)	9 (11.7)	0.015
At least 1 minor complication	13 (76.5)	18 (45)	38 (49)	0.08
More than 1 major complication	5 (30)	5 (13)	10 (13)	0.2
More than 2 major complications	4 (24)	2 (5)	2 (3)	0.004
Per breast	**Anatomic ($n = 23$)**	**Round ($n = 52$)**	**Becker ($n = 88$)**	
At least 1 major complication	8 (35)	9 (17)	9 (10)	0.015
At least 1 minor complication	16 (70)	20 (39)	38 (43)	0.035
More than 1 major complication	6 (23)	6 (12)	9 (10)	0.12
Per procedure	**Anatomic ($n = 24$)**	**Round ($n = 55$)**	**Becker ($n = 90$)**	
At least 1 major complication	8 (33)	9 (16)	9 (10)	0.018
At least 1 minor complication	16 (66)	21 (38)	38 (42)	0.054
More than one major complication	6 (25)	5 (9)	9 (10)	0.072

Table 3 Specific crude complication rates

Major complications	n (%)
Infection requiring IV antibiotic treatment	12 (6.8)
Expander puncture	7 (4)
Surgical drainage of expander pocket (due to infection or hematoma)	3 (1.7)
Wound closure revision	5 (2.8)
Tissue expander explantation	7 (4)
Minor complications	
Hematoma	8 (4.5)
Seroma	19 (10.7)
Infection requiring oral antibiotic treatment	19 (10.7)
Delayed wound healing	10 (5.6)
Pain	30 (16.9)

IV, intravenous

2.8 (95% CI, 1.38–5.81; $p = 0.014$) per woman, 2.72 (95% CI, 1.3–5.5; $p = 0.013$) per breast, and 2.7 (95% CI, 1.3–5.5; $p = 0.015$) per procedure. The respective crude RRs for at least one minor complication were 1.6 (95% CI, 1.15–2.2; $p = 0.037$), 1.7 (95% CI, 1.2–2.3; $p = 0.013$), and 1.7 (95% CI, 1.16–2.3; $p = 0.025$).

Table 4 presents bivariate analyses of the study variables with at least one major complication. Bivariate analyses estimating the risk of experience with at least one minor complication showed that patient weight (OR, 1.2; 95% CI, 1.02–1.44; $p = 0.023$, per 5 kg increase) and surgeon status as a resident (RR, 1.4; 95% CI, 1.03–2; $p = 0.03$) were risk factors for a minor complication.

Table 4 Bivariate analysis of study variables and risk for at least one major complication

Per woman	RR (95% CI)	p Value
Both breasts reconstructed	0.92 (0.4–2.16)	0.848
Previous chemotherapy	1.74 (1.08–2.8)	0.036
Chemotherapy after first surgery	1.25 (0.7–2.2)	0.47
Comorbidities	0.78 (0.37–1.65)	0.51
Smoker	0.93 (0.4–2.2)	0.874
Age (5 years)[a]	1.08 (0.845–1.38)	0.527
TE volume (50 ml)[a]	1.28 (1.1–1.49)	0.002
Weight (5 kg)[a]	1.27 (1.04–1.53)	0.015
Per breast		
Previous radiation	0.99 (0.3–3.1)	0.99
Right breast	1 (0.65–1.5)	0.98
Radiation during follow-up	2.34 (1.06–5.16)	0.037
Prophylactic	0.18 (0.02–1.29)	0.074
Late	1.9 (1.04–3.42)	0.046
Per procedure		
Resident surgeon	1.7 (1.06–2.7)	0.042
Duration of operation (1 h)[a]	1.115 (0.919–1.352)	0.269
Duration of inflation (10 days)[a]	1 (0.98–1.03)	0.823
Mean inflation volume (10 ml)[a]	1.06 (0.87–1.29)	0.544
CC inflated in surgery (10 ml)[a]	1.06 (0.98–2.26)	0.121

TE, tissue expander; CC

[a] Odds ratio (OR) calculated

Multivariate logistic regression analysis, controlling for age, weight, comorbidities, smoking status, bilateral reconstruction, tissue expander volume, radiation, and

chemotherapy, demonstrated that the anatomic tissue expanders increased the risk for at least one major complication (OR, 3.96; 95% CI, 1.18–13.3; $p = 0.026$) per woman, and that tissue expander volume increased the risk for at least one major complication (OR, 1.28; 95% CI, 1.05–1.49 for every 50-ml increase in tissue expander volume; $p = 0.01$). In a similar model for minor complications, only the anatomic tissue expander was associated with increased risk (OR, 3.37; 95% CI, 1.009–11.36; $p = 0.048$).

The logistic model measuring the risks per breast controlled for previous irradiation, breast side, whether the procedure was prophylactic, and reconstruction timing. Again, anatomic tissue expanders were associated with a higher risk of major (OR, 3.88; 95% CI, 1.33–11.34; $p = 0.006$) and minor (OR, 3.43; 95% CI, 1.31–9; $p = 0.012$) complications. Radiation therapy after implantation increased the risk of a major complication (OR, 4.23; 95% CI, 1.51–11.9; $p = 0.013$). The logistic model, per procedure, controlled for surgeon seniority, duration of operation, duration of inflation period, mean inflation volume, and initial volume inflated. Anatomic tissue expander was the sole influencing variable major complications (OR, 3.6; 95% CI, 1.06–12.19; $p = 0.04$). Resident surgeons were not significantly associated with major complications (OR, 1.47; 95% CI, 0.7–3.1; $p = 0.2$). No variable, including tissue expander type, was found to be associated in the multivariate model with minor complications per procedure.

To estimate the change in the count of complications, multivariate models using the same variables were constructed using Poisson regression analysis. Per woman, tissue expander volume increase was associated with a 16% mean increase in the average number of major complications (RR, 1.16; 95% CI, 1.05–1.28 for every 50-ml increase; $p = 0.005$). Tissue expander type was not significantly associated with a change in the count of major complications, and no single variable independently influenced the count of minor complications. The Poisson model per breast demonstrated that anatomic tissue expanders increased the average number of major complications by about 331% (RR, 4.31; 95% CI, 2.02–9.17; $p = 0.0002$). Radiotherapy after reconstruction increased the mean number of major complications by 170% (RR, 2.7; 95% CI, 1.15–6.2; $p = 0.02$).

Minor complications per breast also increased in association with anatomic tissue expander type (RR, 1.9; 95% CI, 1.19–3.04; $p = 0.007$). Anatomic tissue expanders, analyzed per procedure, increased the number of major (RR, 3.6; 95% CI, 1.44–9; $p = 0.006$) and minor (RR, 1.8; 95% CI, 1.09–3; $p = 0.02$) complications. Preventive mastectomy reduced the number of minor complications by about 60% (RR, 0.412; 95% CI, 0.189–0.9; $p = 0.02$). Surgeon seniority had no significant influence on the number of major (RR, 1.28; 95% CI, 0.57–2.86; $p = 0.53$) or minor (RR, 1.3; 95% CI, 0.86–2; $p = 0.2$) complications.

Discussion

Tissue expansion for either immediate or late breast reconstruction often has been studied. Most studies have either followed the outcome of a specific reconstructive method or compared the different limbs of reconstruction (alloplastic vs autologus) [4–8]. To our knowledge, this is the first study that specifically evaluated complication rates and counts between different designs of expanders. We found that when an integrated-valve anatomic implant was used, the incidence of at least one complication, major or minor, was far more common than with either round expanders or the Becker expander-implant. This was consistent when data were analyzed per woman, breast, and procedure.

Furthermore, patients reconstructed with the anatomic tissue expanders were 16% to 30% less likely to complete their reconstruction plan and to achieve a permanent breast implant. Other influencing factors were tissue expander size, according to analysis of data per woman, and adjuvant radiation, according to variables analyzed per breast.

Although breast reconstruction using a tissue expander-implant is considered the safest and most simple method of reconstruction, complications occur. A large multicenter study at Ann Arbor, Michigan compared complication rates for the tissue expander-implant method with those for pedicled transverse rectus abdominis myocutaneous surgery (TRAM) and free TRAM flaps and with the rates for immediate versus delayed reconstruction. This study's definitions for major and minor complications were similar to ours. They presented a total complication rate of 52% for the immediate reconstruction group (46% major) compared with 36% (21% major) for the late one [4].

Another large study from the Sloan-Kettering Cancer Center included 542 women who underwent expander-implant reconstruction without irradiation as the control group for 81 women receiving postmastectomy reconstruction irradiation. For the nonirradiated patients this study found a 6% total complication rate and a 99% reconstruction completion rate, compared with a 11% complication rate and only a 90% reconstruction completion rate for the irradiated group [6].

In both of these studies, the type of expanders used was not specified. Gui et al. [9] studied 49 patients with 68 breasts reconstructed using the remote valve biodimensional expander-implant. They reported a total complication rate of 16% and an implant loss of 4.4% of the total complications. Modena et al. [10] reported an

overall complication rate of 25% as well as rates of 15% for infections, 5% for deflations, and 5% for skin necrosis. It is quite difficult to compare between the reported complication rates because the definitions for complications are not always consistent among the different studies. However, our findings are similar to those reported in the Ann Arbor multicenter study and those reported by Gui et al. [9], including the specific infection rate and implant loss.

Integrated-valve expanders have been designed to decrease distant port complications including chaffing, protrusion, pain, inversion of the port, and valve dysfunction [9, 11]. The first studies on the specific integrated-valve expander presented very low complication rates. Maxwell and Falcone [12] reported 84 cases of reconstruction using an integrated valve with no failures and no extrusions.

McGeorge et al. [13] described their experience with 30 reconstructions using the integrated-valve anatomic expanders and reported a very low complication rate. Although not explicitly stated in their report, 6 (20%) of the 30 reconstructions resulted in a complication. Spear and Majidian [11] presented a series of 171 breasts and reported a 9.7% loss of expanders, with rates of 2% for puncture, 8% for skin flap necrosis, 3.5% for infection, and 1% for hematoma.

Castello et al. [14], in a series of 56 immediate reconstructions using anatomic integrated-valve expanders only, reported overall rates of 37% for complications and 7% for complete failures. Our findings are comparable with the rates reported by Castello et al., although our total failure rates are different because we followed all our patients to completion of treatment, including second rounds of expander introduction.

The difference between the anatomic expander complication rate and the others may result from its design, with the rigid inflation port pressing against the mastectomy flap, which is plausibly more hazardous during immediate reconstruction or among irradiated patients. In addition, because the inflation valve is integrated into the expander's body, injection is directed into the implant pocket, probably increasing the potential for infection in this pocket.

In Nahabedian et al.'s [15] series of 130 patients reconstructed with an integrated-valve biodimensional expander, a 7.7% infection rate was found, which was comparable with the rates stated for round and Becker expanders. We did not find other studies that compare the complication rates between the different expanders or implant designs. Certainly, some of the complications can be attributed to less experience with management of the anatomic integrated expanders, which is reflected in the lower number of patients in this group. Our study groups were insufficiently large and lacked power to reach statistical significance regarding influence on specific complications. Larger study groups are needed to investigate the influence of the anatomic expander design on infections or extrusions.

Previously, radiation was found to be a risk factor for tissue expander breast reconstruction. Nahabedian et al. [15] found that radiation treatment had a significant association with infections in implant breast reconstruction. Similarly, Cordeiro et al. [6] found an overall reduced successful reconstruction rate and a rise in all complication components compared with nonirradiated patients. Krueger et al. [5] reported complication rates as high as 68% among irradiated patients, compared with 31% among those not irradiated. Bronz and Bronz [16] also concluded, after reviewing 170 reconstructed breasts, that expander-implant reconstruction should be done more cautiously for the irradiated patient.

Others found no implication of radiotherapy over the incidence of tissue expander complications [17, 18]. Our findings are consistent with those showing an influence of irradiation on complications of tissue expander reconstruction and, accordingly, we controlled for irradiation treatment in our breast stratified analyses.

In most publications, the incidence of complications in breast reconstruction is stated as a percentage of all complications. Whereas in small studies it can be stated that a single patient had one or more complications, in larger studies it is impossible to know whether a patient or an expander design is "complication prone." For example, if a woman has a wound infection, it may be reasonable to assume that she is more prone to wound dehiscence and implant removal.

Alderman et al. [4] reported the percentage of patients experiencing no complication, one complication, or more than one complication. They did not specify these results for TRAM reconstruction or expander-implants. Our study is the first to evaluate the number of complications in association with the variables examined. Tissue expander type was associated with the number of major or minor complications encountered when analyzed per procedure or breast, but not when analyzed per woman. This emphasizes the sensitivity of this study to the influence of the anatomic device design. If data had been analyzed only per patient, this information would have been "dampened" by other patient factors that may decrease the patient's susceptibility to anatomic implant complications.

Not many studies have dealt with the seniority of the operating surgeon and the complication rate. It may be assumed that because the performance of surgery requires training, there should be a crucial influence of the surgeon's experience on the outcomes and complications. Most recent studies addressing this question have examined laparoscopic procedures because they are difficult techniques to master [19, 20]. In plastic surgery, resident

complication rates compared with those for senior surgeons have rarely been investigated. We found only three studies that address this question directly. The first reported a protective effect of microvascular anastomosis performed by the attending surgeons [21]. The second addressed the outcomes of rhytidectomies performed by chief residents and found that results and complications were comparable with those of senior surgeons [22]. The third study found that undergoing operation by a resident plastic surgeon was indeed a significant risk factor for implant loss, but not a risk factor for complicated surgical outcome [8].

In our study, logistic regression analysis did not detect a correlation between the main surgeon's seniority and either the rate of complications or the number of complications. We can conclude that expander-implant breast reconstruction can be taught safely in a training resident program without compromising the outcomes of the patients.

The anatomic group tended to be more obese than their counterparts in the round and Becker expander-implant groups. Obesity is known to be a factor influencing reconstruction completion and success with either autologous or prosthetic methods [4, 10, 23, 24]. Although we found this to be of influence in the analysis of data per woman in bivariate analysis, it did not achieve statistical significance in multivariate analysis when other factors were controlled. In addition, because we did not have sufficient information to calculate the patients' body mass index (BMI), this variable may be misleading.

Because this is a historical study, the three study groups are somewhat different from each other. The anatomic expander group had a higher rate of patients who received radiotherapy before their reconstruction, a fact well known to increase complications, as discussed previously. On the other hand, this group had a larger percentage of late versus immediate reconstructions, which has a protective effect and decreases the complications encountered [4, 10].

To overcome those differences, both multivariate logistic regression analyses and multivariate Poisson regression analyses were used to control for these differences. A prospective controlled study enrolling comparable patients for the two groups would have been better for clarifying the differences between the expander types.

In conclusion, we found a significantly higher complication rate with the use of the integrated-valve biodimensional expander than with either the distant port round expander or the Becker expander-implant. We believe that in our hands, benefits attributed to the integrated valve do not outweigh the complications encountered while using it. It is logical to assume that after infection and multiple operative procedures, both of which were found to be increased in the anatomic expander group, the final aesthetic results may even be inferior. Selective lower-pole expansion is achievable using a distant port anatomic Becker expander-implant or similar designs manufactured by other companies. Larger studies with prospective designs may be needed to clarify further the significance of our findings.

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