"To Pre or Not to Pre": Introduction of a Prepectoral Breast Reconstruction Assessment Score to Help Surgeons Solving the Decision-Making Dilemma. Retrospective Results of a Multicenter Experience

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Background: Implant-based reconstruction is the most performed breast reconstruction, and both subpectoral and prepectoral approaches can lead to excellent results. Choosing the best procedure requires a thorough understanding of every single technique, and proper patient selection is critical to achieve surgical success, in particular when dealing with prepectoral breast reconstruction.
Methods: Between January of 2014 and December of 2018, patients undergoing mastectomy and eligible for immediate prepectoral breast reconstruction with tissue expander or definitive implant, were selected. The Prepectoral Breast Reconstruction Assessment score was applied to evaluate patient-related preoperative and intraoperative risk factors that could influence the success of prepectoral breast reconstruction. All patients were scored retrospectively, and the results obtained through this assessment tool were compared to the records of the surgical procedures actually performed.
Results: Three hundred fifty-two patients were included; 112 of them underwent direct-to-implant immediate reconstruction, and 240 underwent the two-stage procedure with temporary tissue expander. According to the Prepectoral Breast Reconstruction Assessment score, direct-to-implant reconstruction should have been performed 6.2 percent times less, leading to an increase of 1.4 percent in two-stage reconstruction and 4.8 percent in submuscular implant placement.
Conclusions: To date, there is no validated system to guide surgeons in identifying the ideal patient for subcutaneous or retropectoral breast reconstruction and eventually whether she is a good candidate for direct-to-implant or two-stage reconstruction. The authors processed a simple risk-assessment score to objectively evaluate the patient's risk factors, to standardize the decision-making process, and to identify the safest and most reliable breast reconstructive procedure. (*Plast. Reconstr. Surg.* 147: 1278, 2021.)
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Along with the increase of breast cancer incidence, mastectomy rates have presented a large increase in the past decade.[1,2] Implant-based reconstruction represents the most common form of breast reconstruction after mastectomy.[3] The

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current standard procedure consists of placement of prosthetic devices into a submuscular pocket behind the pectoralis major muscle.[4] It allows good coverage of the implant; however, detachment of the pectoralis major muscle can lead to several complications, ranging from muscular deficit to severe postoperative pain. Moreover, animation deformity and insufficient lower pole fullness can occur.[5,6] The prepectoral breast reconstruction technique was introduced by Snyderman and Guthrie in 1971[7] but was associated with a high incidence of mastectomy skin flap necrosis, implant extrusion, capsular contracture, and rippling.[8,9] Nowadays, the introduction of new devices such as acellular dermal matrix or titanium-coated polypropylene mesh, which can wrap the implant and create a further protective layer for subcutaneous placement, has given new life to prepectoral breast reconstruction.[10–14]

In comparison to submuscular placement, prepectoral breast reconstruction is advocated to be less invasive, easier to perform, time sparing, and associated with lower postoperative pain in the absence of animation deformity. Along with these advantages, excellent cosmetic outcomes and more natural breast shapes have been reported in the literature.[15–17]

Subpectoral and prepectoral implant-based breast reconstruction can both lead to good results. Choosing the best procedure requires a thorough understanding of the benefits and drawbacks of every single technique, to offer every single patient the best tailored reconstructive approach. Proper patient selection is absolutely critical to achieve surgical success. When dealing with prepectoral breast reconstruction, it is mandatory.[18] Numerous variables should be screened preoperatively and intraoperatively, and the literature offers different reports and hints that should advise surgeons in the decision-making regarding the proper surgical indication. Nevertheless, the operative risks that are reported in the literature are based on the average of the general population. As a consequence, surgical complications drawn from these studies may overestimate or underestimate the real risk for the single case, especially when the patient presents multiple comorbidities or peculiar characteristics. Surgical risks should be assessed with a precise method, one that is more personalized than the population-based averages.[19–21]

The authors collected data on implant-based breast reconstructions performed since January of 2014. These data were evaluated retrospectively, taking into account all relevant patient-related preoperative and intraoperative risk factors that may play a role in leading to adverse events or reconstructive failure, to create a risk-assessment score to eventually safely outline the surgical indication toward a prepectoral or submuscular breast reconstruction. It is an objective and quantitative assessment method, which could make the surgeon's decision flowchart easier and allow every patient to receive the optimal personalized breast reconstruction.

PATIENTS AND METHODS

Between January of 2014 and December of 2018, patients undergoing mastectomy were enrolled at our institution, Azienda Ospedaliero-Universitaria Careggi, Florence, and Breast Unit Integrata, Livorno, Cecina, Piombino, Elba, Azienda USL Toscana nord ovest. Before surgery, all patients were evaluated for both autologous and alloplastic breast reconstruction, taking into account patient preference, body habitus, comorbidities, prior abdominal surgery, and surgeon experience. Women aged 18 years or older with confirmed breast cancer diagnosis or genetic predisposition (i.e., mutation in *BRCA1* or *BRCA2* genes), willing and eligible to undergo skin-sparing or nipple-sparing mastectomy followed by immediate prepectoral breast reconstruction with tissue expander or definitive prosthesis, in both cases assisted by the positioning of a synthetic mesh, met the basic inclusion criteria. Our surgical technique for prepectoral breast reconstruction with definitive or temporary implants and synthetic titanium-coated polypropylene mesh has been described previously.[5,11,22–24] Briefly, mastectomy was performed through an inframammary incision, a lateral S-shaped incision, or a vertical incision, and skin flaps were raised in a subcutaneous plane. After careful clinical evaluation of the skin flaps, patients underwent immediate breast reconstruction using a definitive prosthesis (Natrelle 410; Allergan, Inc., Irvine, Calif; Mentor, Breast Implants, Mentor Worldwide, Santa Barbara, Calif.) or a tissue expander (Allergan and Mentor; Contour Profile Expanders). In both cases, the implant was wrapped in a titanium-coated polypropylene mesh—specifically, TiLoop Bra (TiLOOP Bra; pfm medical, Cologne, Germany)—and was then placed in a totally subcutaneous prepectoral position. Apical, medial, and lateral borders of the mesh were secured to the pectoral fascia with interrupted absorbable sutures. One vacuum drain was inserted in the inframammary fold, and patients received oral antibiotics until surgical drain removal. In cases of two-stage reconstruction with a tissue expander, the first postoperative expansion was scheduled

3 weeks after discharge, and two or three other expansions were performed until the final volume was reached. The expander was replaced with a definitive implant 6 months after the last expansion. Follow-up visits were scheduled 1 month, 3 months, 6 months, 1 year, and 2 years after the final operation. During follow-up, aesthetic outcome, capsular contracture grade, any cancer recurrences, and health-related quality-of-life outcomes were evaluated and recorded. Aesthetic outcomes were objectively assessed by an expert panel of five plastic surgeons who did not perform any of the operations and were registered only when patients required reoperation or implant removal (implant rippling, dystopia, or severe capsular contracture grade). Capsular contracture was assessed with the Baker scale. The BREAST-Q questionnaire was completed 1 month before surgery by all enrolled patients and repeated 1 year after definitive surgery. The survey assesses patient satisfaction by studying the Satisfaction with Breasts, Satisfaction with Outcome, Psychosocial Well-being, Physical Well-being, and Sexual Well-being subscales.[25]

The results obtained from the BREAST-Q questionnaires were converted from raw scores (1 through 4 or 5) to a continuous range from 0 to 100 using the Q Score scoring software. Both absolute results and their changes before and after treatment were analyzed using the *t* test. Values of $p < 0.05$ were considered statistically significant.

On the basis of the collected data,[26,27] we elaborated the Prepectoral Breast Reconstruction Assessment score, that takes into consideration relevant patient-related preoperative and intraoperative risk factors that may potentially influence implant-based prepectoral breast reconstruction leading to adverse events or reconstructive failure. Table 1 shows the eight main influencing domains and the specific numeric value associated with each factor. We retrospectively scored all patients enrolled in this study. Each patient was assigned a score ranging from 0 to 12. The final value obtained with the score assessment leads surgeons in the decision-making process, suggesting the most suitable reconstructive procedure for that selected patient (Table 2). We compared the final results obtained by the retrospective application of the Prepectoral Breast Reconstruction Assessment score to our cohort of patients (group A) and the records of surgical procedures previously performed in our centers (group B), searching for differences between the ideal scoring system reconstructive indications (group A) and the reconstructive patterns taken by our units (group B). These differences were evaluated with the Fisher's test, to outline statistical significance.

Table 1. Assessment of Individual Preoperative and Intraoperative Risk Factors for Implant-Based Prepectoral Breast Reconstruction Failure*

Risk Factor	Score 0	Score 1	Score 2	Range of Score per Factor
Patient's age, yr	>70	50–70	<50	0–2
Diabetes	Yes	No	—	0–1
Smoker	Current smoker	Ex-smoker	Never smoker	0–2
BMI	Low: <22	High: >25	Medium: 22–25	0–2
Breast ptosis: indication for skin-reducing mastectomy	Yes	No	—	0–1
Previous breast surgery	Yes	No	—	0–1
Radiotherapy	Yes	No	—	0–1
Mastectomy flap thickness, cm	<1	1–2	>2	0–2

BMI, body mass index.
*Each factor receives a score from 0–1 or 2. Total patient's score varies from 0–12.

Table 2. Individual Patient's Score for Selection of the Safest Implant-Based Breast Reconstruction

Score	Implant-Based Breast Reconstruction
0–4	No indication for prepectoral reconstruction; submuscular placement of the implant
5–8	Two-stage reconstruction with prepectoral tissue expander first and subcutaneous definitive prosthesis second
9–12	Prepectoral direct-to-implant breast reconstruction

RESULTS

From January of 2014 to December of 2018, 352 patients were included in this study. Baseline characteristics are listed in Table 3. Average patient age was 55.9 years (range, 23 to 80 years) and the mean body mass index was 23.75 kg/m^2 (range, 19 to 35 kg/m^2). Twenty-six patients (7.4 percent) suffered from diabetes and 112 (31.8 percent) were active or past smokers. Eighty-seven patients were diagnosed with *BRCA1/2* mutation (24.7 percent), 100 (28.4 percent) had already undergone breast surgery, and 47 (13.4 percent) had already undergone radiotherapy. Table 4 lists the characteristics of the surgical procedures. Postmastectomy flaps were intraoperatively evaluated adequate, and no reconstruction was aborted. One hundred twelve patients (31.8 percent) underwent direct-to-implant immediate reconstruction, whereas 240 patients (68.2 percent) elected the two-stage procedure with the

Table 3. Demographic Characteristics of the Total 352 Patients

Characteristic	Value (%)
No. of patients	352
Age, yr	
Mean	55.9
Range	23–80
BMI, kg/m^2	
Mean	23.75
Range	19–35
Diabetes	26 (7.4)
Smoking	
Active smoker	51 (14.5)
Ex-smoker	61 (17.3)
Never smoker	240 (68.2)
BRCA1/BRCA2 mutation carriers	87 (24.7)
Previous radiotherapy	47 (13.4)
Previous breast surgery	100 (28.4)
Wide local excision	39 (11.1)
Contralateral mastectomy	27 (7.7)
Unilateral QUART	25 (7.1)
Breast augmentation	9 (2.6)

BMI, body mass index; QUART, quadrantectomy with axillary lymph node dissection plus radiation therapy.

Table 4. Baseline Characteristics of Surgical Procedures Included in the Analysis

Characteristic	Value (%)
Total no. of mastectomies	467
Mastectomy	
Monolateral	237 (67.3)
Bilateral	115 (32.7)
Type of mastectomy	
NSM	266 (56.9)
SSM	201 (43.1)
Incision	
Inframammary fold	205 (43.9)
Vertical	4 (0.9)
Lateral S-shaped	258 (55.2)
Type of prepectoral breast reconstruction	
Two-stage with TE	323 (69.2)
DTI	144 (30.8)
Axillary surgery	224 (48)
Axillary resection	44 (9.4)
Sentinel lymph node biopsy	180 (38.5)
Adjuvant radiotherapy	48 (10.3)

NSM, nipple-sparing mastectomy; SSM, skin-sparing mastectomy; TE, tissue expander; DTI, direct-to-implant.

placement of a tissue expander first. A total of 467 mastectomies were performed: 115 (32.7 percent) bilateral and 237 unilateral (67.3 percent). Two hundred sixty-six mastectomies (56.9 percent) were nipple-sparing and 201 (43.1 percent) were skin-sparing. The drain was removed between postoperative days 2 and 9 (mean, 4.2 days).

The average postsurgical follow-up period was 37.5 months (range, 12 to 60 months). Postoperative complications that required a second operation occurred in 29 cases (8.2 percent): five occurred in the direct-to-implant group and 21 after the first or second operation in the two-stage reconstructions. Of those 29 complications, six (1.7 percent) were caused by infection, eight (2.3 percent) were caused by seroma, 11 (3.1 percent) were caused by skin-nipple necrosis, and four (1.1 percent) were caused by hematoma. Because of these complications, 10 implants (2.8 percent) had to be removed and salvage procedures were applied, by moving the reconstruction to a submuscular plane or by performing autologous tissue reconstruction. Two years after surgery, Baker grade IV capsular contracture was detected in 12 breasts (2.6 percent), whereas 375 breasts were evaluated as grade I (80.3 percent), 70 breasts were evaluated as grade II (15 percent), and 10 breasts were evaluated as grade III (2.1 percent). The total rate of significant (Baker grade III to IV) capsular contracture was reported as low as 4.7 percent (22 breasts).

After an average of 10 months after surgery, implant rippling or palpability was detectable in 38 breasts (8.1 percent), and an average of 30 ml of lipofilling was performed, successfully reducing implant visibility. All 352 patients completed the BREAST-Q questionnaire 1 month before mastectomy and repeated the same survey 1 year after the definitive reconstruction to assess their health-related quality of life. Table 5 reports the preoperative and postoperative results. Overall scores for Satisfaction with Breasts, Psychosocial Well-being, and Sexual Well-being were all significantly increased after surgery ($p < 0.05$).

All 352 patients were evaluated retrospectively with the Prepectoral Breast Reconstruction Assessment score for risk factors associated with prepectoral breast reconstruction failure. Ninety patients (25.6 percent) scored high (9 to 12), which would have led to direct-to-implant prepectoral reconstruction, 245 (69.6 percent) scored 5 to 8 and would have undergone two-stage prepectoral breast reconstruction, and 17 (4.8 percent) scored a poor result because of severe risk factors. Those assessment results were compared to the reconstructive choices taken previously by our unit and described in the results above. Table 6 lists the result of this comparison: it appears, according to our risk assessment score, that direct-to-implant reconstruction should have been performed 6.2 percent times less, leading to the increase of 1.4 percent in two-stage reconstruction and 4.8 percent in submuscular implant placement. These differences were evaluated using the Fisher's test, considering a value of $p < 0.05$ significant. The direct-to-implant and two-stage prepectoral reconstruction groups presented nonsignificant differences ($p = 0.08$ and $p = 0.74$, respectively). In contrast, there was a statistically significant

Table 5. BREAST-Q Scores Collected 1 Month Preoperatively and 1 Year Postoperatively, Expressed as Mean ± SD

BREAST-Q Domain	Preoperative Scores	Postoperative Scores	Delta*	*p*†
Satisfaction with Breasts	58.9 ± 11.5	72.4 ± 9.9	13.5	0.0016
Psychosocial Well-being	64.3 ± 14.1	77.6 ± 12	13.3	0.0078
Sexual Well-being	55.9 ± 12.1	65.1 ± 11.2	9.2	0.0303
Physical Impact	77.8 ± 11.3	75.3 ± 12.4	–2.5	0.4861
Overall Satisfaction with Outcome	—	74.2 ± 11.7	—	—

*Changes in scores (postoperative score minus preoperative score).
†Values of $p < 0.05$ were considered statistically significant.

Table 6. Comparison between Risk Assessment Score Results and the Reconstructive Choices Taken Previously by Our Unit

Breast Reconstruction	Score	352 Cases Reported from January of 2014 to November of 2018 (%)	352 Cases Evaluated with Risk-Assessment Score (%)	Difference between the Indications (%)
Submuscular implant placement	0–4	0 (0)	17 (4.8)	17 (4.8)
Two-stage prepectoral reconstruction	5–8	240 (68.2)	245 (69.6)	5 (1.4)
Direct-to-implant prepectoral reconstruction	9–12	112 (31.8)	90 (25.6)	–22 (–6.2)

difference (p = 0.001) between the submuscular reconstruction groups: none of the group B patients underwent submuscular reconstruction for the first instance, whereas the Prepectoral Breast Reconstruction Assessment score suggested this procedure in 17 cases in group A.

DISCUSSION

Decades after its presentation and relative failures, prepectoral breast reconstruction is experiencing a revival because of several surgical and technological improvements. Refinements in skin-sparing and nipple-sparing mastectomy have maximized the amount of tissue that can be safely preserved, with no decrease in oncologic safety,[28] and the introduction of acellular dermal matrix and more recently synthetic mesh products has improved aesthetic results and reduced the incidence of capsular contracture.[29] Furthermore, there is the possibility of enhancing aesthetic outcomes by performing some fat grafting sessions that increase the thickness of soft-tissue flaps while minimizing the palpability and visibility of implants.[30–33] In addition, innovative technologies such as indocyanine green angiography can be used to perform intraoperative assessment of the perfusion of mastectomy flaps, evaluating their viability and ischemic stress resistance.[34–36]

Prepectoral implant-based breast reconstruction can provide excellent results; however, a clear and comprehensive identification of its limitations and ideal applications will allow breast surgeons to optimize outcomes and minimize complications. Proper patient selection is crucial for success, and all efforts must be made to predict the perfusion of mastectomy flaps, to avoid their ischemic stress, necrosis, and potential implant exposure.[37,38]

In 2017, Rancati et al.[21] proposed an interesting preoperative reconstructive algorithm focusing on flap thickness prediction through the use of preoperative digital mammography. In this way, surgeons can possibly foresee the viability of postmastectomy flaps and take into consideration this information, standardizing the "decision-making" process to select the best reconstructive procedure, possibly minimizing ischemic complications.

Mlodinow et al.[39] described a valuable report that introduced the Breast Reconstruction Risk Assessment score, estimating the postoperative complication risk in autologous and implant-based immediate breast reconstruction procedures. The Breast Reconstruction Risk Assessment score presents potential utility in both surgical planning and informed consent, but as the authors themselves state, it should not be used to determine surgical candidacy for any patient. The Breast Reconstruction Risk Assessment score can predict the probability of five surgical complications and the necessity for reoperation, but it does not give precise indications on which procedure is the most suitable for the patient, basically basing the final decision entirely on the surgeon's individual experience or inclination. In contrast, prepectoral reconstruction still represents a relatively recent procedure with little long-term follow-up

Table 7. Prepectoral Breast Reconstruction Assessment Scores Collected by the 10 Patients Who Underwent Implant Loss and Successive Reconstruction with Submuscular Tissue Expander or Autologous Flaps in the Real Series*

Patient	Age (0–2)	Diabetes (0–1)	Smoker (0–2)	BMI (0–2)	Breast Ptosis (0–1)	Previous Breast Surgery (0–1)	Previous Radiotherapy (0–1)	Mastectomy Flap Thickness (0–2)	Total Pre-BRA Score
1	>70 (0)	Yes (0)	Ex-smoker (1)	Low (0)	Yes (0)	No (1)	No (1)	1–2 cm (1)	4
2	50–70 (1)	No (1)	Ex-smoker (1)	Low (0)	Yes (0)	Yes (0)	Yes (0)	1–2 cm (1)	4
3	50–70 (1)	No (1)	Current smoker (0)	Low (0)	Yes (0)	Yes (0)	No (1)	1–2 cm (1)	4
4	>70 (0)	Yes (0)	Never smoker (2)	High (1)	Yes (0)	Yes (0)	Yes (0)	1–2 cm (1)	4
5	<50 (2)	No (1)	Current smoker (0)	Medium (2)	Yes (0)	Yes (0)	Yes (0)	1–2 cm (1)	6
6	>70 (0)	Yes (0)	Current smoker (0)	High (1)	Yes (0)	Yes (0)	No (1)	>2 cm (2)	4
7	50–70 (1)	No (1)	Ex-smoker (1)	Low (0)	Yes (0)	Yes (0)	Yes (0)	1–2 cm (1)	4
8	50–70 (1)	No (1)	Ex-smoker (1)	High (1)	Yes (0)	Yes (0)	Yes (0)	1–2 cm (1)	5
9	50–70 (1)	No (1)	Current smoker (0)	Low (0)	No (1)	Yes (0)	Yes (0)	1–2 cm (1)	4
10	>70 (0)	Yes (0)	Never smoker (2)	Low (0)	Yes (0)	Yes (0)	No (1)	1–2 cm (1)	4

BMI, body mass index; Pre-BRA, Prepectoral Breast Reconstruction Assessment.
*Each characteristic is evaluated according to the Pre-BRA scoring system.

in the literature. As more and more surgeons are performing it, a simple and objective guideline is necessary to help them distinguish which procedure is more feasible or simply evaluate when subcutaneous implant placement, either direct-to-implant or two-stage fashion, is to be considered the best option. Numerous variables can be screened preoperatively and intraoperatively, to predict the risk of mastectomy flap ischemic stress or necrosis. As with any surgical preoperative evaluation, even for prepectoral breast reconstruction, a general health consideration including a full history and general clinical examination is mandatory.

Elderly patients, or patients with a high body mass index, active smokers, or those affected by diabetes mellitus will present poor soft-tissue quality as a consequence of compromised microvascular circulation, with an increased risk of skin flap necrosis and extrusion or infection of the implant. In our risk-assessment score, elderly patients that are older than 70 years collect 0 points for their age; patients aged 50 to 70 years collect 1 point; and those younger than 50 years receive 2 points. Obesity (body mass index >35 kg/m^2) is considered an exclusion criterion for prepectoral breast reconstruction,[18,28] and for every point increase in body mass index, the odds of complications increase by 5.9 percent and the odds of reconstructive failure increase by 7.9 percent.[17] Similarly, low body mass index is associated with an even higher risk of developing a surgical complication.[40,41] We assigned 2 points to patients with a medium body mass index range (22 to 25 kg/m^2), 1 point to patients with a higher body mass index (>25 kg/m^2), and 0 points to those with a lower body mass index (<22 kg/m^2). Furthermore, our assessment score considered also cases with breast ptosis, which would need skin-reducing mastectomy; these cases are associated with a substantial risk of implant exposure at the inframammary fold.[42] We assigned 0 points to patients that were scheduled for Wise-pattern skin-reducing mastectomy, in which the nipple-areola complex was either lifted with a flap or grafted over an inferior dermal flap. Diabetes mellitus, especially if poorly controlled with elevated blood glucose levels documented by hemoglobin A1c levels higher than 7 percent, will affect wound healing and compromise vascular supply.[43] In our score, all patients affected by diabetes mellitus gain 0 points. Smoking is a well-known contraindication to prepectoral breast reconstruction.[44] In our study, active smokers gained 0 points, ex-smokers received 1 point, and never-smokers collected 2 points. Taking into account the patient's medical history, those with previous breast operations and previous radiotherapy received 0 points each in our score, because they are associated with a high risk of wound dehiscence and infection.[45] Postoperative radiotherapy was not taken into account, as its necessity is confirmed after mastectomy, mostly. However, previous radiation therapy is actually being reconsidered not as an absolute contraindication for prepectoral breast reconstruction, as it is likely a superior option to subpectoral reconstruction: the irradiated muscle can become particularly fibrotic, transferring additional force onto the implant and resulting in implant malposition and capsular contracture.[41]

Intraoperative evaluation of skin flap thickness and potential viability is also crucial in decision-making and timing of reconstruction: reasonable thickness to the skin with moderate subcutaneous fat is favorable, and we assigned 0 points to cases that presented less than 1 cm thickness of the

mastectomy skin flaps and/or when skin viability was evaluated low for poor bleeding of the flap's margins, 1 point when thickness was 1 to 2 cm, and 2 points when there was more than 2 cm of coverage. A digital database was created in January of 2014 collecting data on patient characteristics and surgical procedures with any related complications. In the current study, we were able to evaluate retrospectively 352 patients, taking into account the above-mentioned risk factors, to compile a reliable risk-assessment score, ranging from 0 to 12, and stratify a class of surgical risk. Ninety of the patients (25.6 percent) achieved a high score (9 to 12 points) and would have received an indication for direct-to-implant prepectoral breast reconstruction. If compared to direct-to-implant reconstructions performed without using the risk-assessment score [112 (31.8 percent)], we record a difference of 6.2 percent, which was evaluated as statistically nonsignificant. This difference actually consisted of 22 cases that would definitely have been directed for two-stage prepectoral reconstruction after having received the Prepectoral Breast Reconstruction Assessment score. Two hundred forty patients (68.2 percent) underwent two-stage reconstruction with prepectoral insertion of a tissue expander, and none of them (0 percent) experienced submuscular reconstruction as the first option. Nevertheless, as a consequence of postoperative complications, 10 (2.8 percent) implants had to be removed and reconstruction with a tissue expander was switched to a submuscular plane or to an autologous tissue reconstruction. At the score analysis, eight patients reached a threshold value of 4 points, whereas the other two collected 5 and 6 points each. All 10 of these patients presented some characteristics that in real series were considered allowing the two-stage prepectoral reconstruction and are presented in Table 7.

According to the risk-assessment score analysis, 245 cases (69.6 percent) should have undergone two-stage reconstruction, 1.4 percent more than in the real series, a statistically nonsignificant value. In contrast, the difference was significant in patients in the low-scoring group (0 to 4 points), who would have received an indication for submuscular implant placement. There were 17 of these patients, 4.8 percent more than in group B. Among these 17 patients, eight (47.1 percent) corresponded to the cases that underwent implant extrusion.

Clearly, a limit of this study is represented by the retrospective nature of the analysis: it is impossible to discriminate whether those complications would have been avoided with the score application. We believe a prospective study is mandatory to definitely validate this scoring system.

Nevertheless, the Prepectoral Breast Reconstruction Assessment score represents the first step to achieve an objective and validated patient evaluation system that may lead the way for an easier decision-making process for surgeons dealing with prepectoral breast reconstructions. By classifying patients into simple risk groups, the Prepectoral Breast Reconstruction Assessment score can clarify the indications for prepectoral procedures. We believe such a tool may integrate the decision-making process by helping the surgeon to select the most appropriate option, not only by counting on his or her individual experience or inclination, but rather tailoring the breast reconstruction to the individual patient's characteristics, to minimize the risk of surgical complications.

CONCLUSIONS

Prepectoral breast reconstruction is experiencing an important revival and is opening new promising horizons. However, as for all operations, accurate patient selection is the key for success, and adequately perfused mastectomy flaps are crucial for a good prepectoral reconstruction. To date, there is no validated system to guide surgeons to accurately identify patients that can undergo subcutaneous breast reconstruction and, eventually, whether they are good candidates for direct-to-implant or two-stage reconstruction with a tissue expander. This is a retrospective analysis, and further prospective studies are needed. Nevertheless, after reviewing a multicenter database and surgical records, we processed an innovative and simple risk-assessment score to objectively evaluate patient risk factors, to standardize the decision-making process, and to identify the safest and most reliable patient-tailored, breast reconstructive procedure.

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REFERENCES

1. Lucas DJ, Sabino J, Shriver CD, Pawlik TM, Singh DP, Vertrees AE. Doing more: Trends in breast cancer surgery, 2005 to 2011. *Am Surg.* 2015;81:74–80.
2. Jagsi R, Jiang J, Momoh AO, et al. Trends and variation in use of breast reconstruction in patients with breast cancer undergoing mastectomy in the United States. *J Clin Oncol.* 2014;32:919–926.

3. Albornoz CR, Bach PB, Mehrara BJ, et al. A paradigm shift in U.S. breast reconstruction: Increasing implant rates. *Plast Reconstr Surg.* 2013;131:15–23.
4. Baker BG, Irri R, MacCallum V, Chattopadhyay R, Murphy J, Harvey JR. A prospective comparison of short-term outcomes of subpectoral and prepectoral Strattice-based immediate breast reconstruction. *Plast Reconstr Surg.* 2018;141:1077–1084.
5. Bernini M, Calabrese C, Cecconi L, et al. Subcutaneous direct-to-implant breast reconstruction: Surgical, functional, and aesthetic results after long-term follow-up. *Plast Reconstr Surg Glob Open* 2015;3:e574.
6. Nahabedian MY, Cocilovo C. Two-stage prosthetic breast reconstruction: A comparison between prepectoral and partial subpectoral techniques. *Plast Reconstr Surg.* 2017;140(Prepectoral Breast Reconstruction):22S–30S.
7. Snyderman RK, Guthrie RH. Reconstruction of the female breast following radical mastectomy. *Plast Reconstr Surg.* 1971;47:565–567.
8. Artz JS, Dinner MI, Sampliner J. Breast reconstruction with a subcutaneous tissue expander followed with a polyurethane-covered silicone breast implant. *Ann Plast Surg.* 1988;20:517–521.
9. Radovan C. Breast reconstruction after mastectomy using the temporary expander. *Plast Reconstr Surg.* 1982;69:195–208.
10. Ibrahim AM, Koolen PG, Ganor O, et al. Does acellular dermal matrix really improve aesthetic outcome in tissue expander/implant-based breast reconstruction? *Aesthetic Plast Surg.* 2015;39:359–368.
11. Casella D, Bernini M, Bencini L, et al. TiLoop Bra mesh used for immediate breast reconstruction: Comparison of retropectoral and subcutaneous implant placement in a prospective single-institution series. *Eur J Plast Surg.* 2014;37:599–604.
12. Berna G, Cawthorn SJ, Papaccio G, Balestrieri N. Evaluation of a novel breast reconstruction technique using the Braxon acellular dermal matrix: A new muscle-sparing breast reconstruction. *ANZ J Surg.* 2017;87:493–498.
13. Reitsamer R, Peintinger F. Prepectoral implant placement and complete coverage with porcine acellular dermal matrix: A new technique for direct-to-implant breast reconstruction after nipple-sparing mastectomy. *J Plast Reconstr Aesthet Surg.* 2015;68:162–167.
14. Marcasciano M, Frattaroli J, Mori FLR, et al. The new trend of pre-pectoral breast reconstruction: An objective evaluation of the quality of online information for patients undergoing breast reconstruction. *Aesthetic Plast Surg.* 2019;43:593–599.
15. Walia GS, Aston J, Bello R, et al. Prepectoral versus subpectoral tissue expander placement: A clinical and quality of life outcomes study. *Plast Reconstr Surg Glob Open* 2018;6:e1731.
16. Gabriel A, Maxwell GP. Prepectoral breast reconstruction in challenging patients. *Plast Reconstr Surg.* 2017;140(Prepectoral Breast Reconstruction):14S–21S.
17. Glasberg SB. The economics of prepectoral breast reconstruction. *Plast Reconstr Surg.* 2017;140(Prepectoral Breast Reconstruction):49S–52S.
18. Sbitany H. Important considerations for performing prepectoral breast reconstruction. *Plast Reconstr Surg.* 2017;140(Prepectoral Breast Reconstruction):7S–13S.
19. Bilimoria KY, Liu Y, Paruch JL, et al. Development and evaluation of the universal ACS NSQIP surgical risk calculator: A decision aid and informed consent tool for patients and surgeons. *J Am Coll Surg.* 2013;217:833–842.e1.
20. Menke H, John KD, Klein A, Lorenz W, Junginger T. Preoperative risk assessment with the ASA classification: A prospective study of morbidity and mortality in various ASA classes in 2,937 patients in general surgery (in German). *Chirurg* 1992;63:1029–1034.
21. Rancati AO, Angrigiani CH, Hammond DC, et al. Direct to implant reconstruction in nipple sparing mastectomy: Patient selection by preoperative digital mammogram. *Plast Reconstr Surg Glob Open* 2017;5:e1369.
22. Casella D, Calabrese C, Bianchi S, Meattini I, Bernini M. Subcutaneous tissue expander placement with synthetic titanium-coated mesh in breast reconstruction: Long-term results. *Plast Reconstr Surg Glob Open* 2015;3:e577.
23. Casella D, Di Taranto G, Marcasciano M, et al. Nipple-sparing bilateral prophylactic mastectomy and immediate reconstruction with TiLoop Bra mesh in *BRCA1/2* mutation carriers: A prospective study of long-term and patient reported outcomes using the BREAST-Q. *Breast* 2018;39:8–13.
24. Marcasciano M, Kaciulyte J, Marcasciano F, Lo Torto F, Ribuffo D, Casella D. "No drain, no gain": Simultaneous seroma drainage and tissue expansion in pre-pectoral tissue expander-based breast reconstruction. *Aesthetic Plast Surg.* 2019;43:1118–1119.
25. Pusic AL, Chen CM, Cano S, et al. Measuring quality of life in cosmetic and reconstructive breast surgery: A systematic review of patient-reported outcomes instruments. *Plast Reconstr Surg.* 2007;120:823–837.
26. Casella D, Di Taranto G, Marcasciano M, et al. Subcutaneous expanders and synthetic mesh for breast reconstruction: Long-term and patient-reported BREAST-Q outcomes of a single-center prospective study. *J Plast Reconstr Aesthet Surg.* 2019;72:805–812.
27. Casella D, Di Taranto G, Marcasciano M, et al. Evaluation of prepectoral implant placement and complete coverage with TiLoop bra mesh for breast reconstruction: A prospective study on long-term and patient-reported BREAST-Q outcomes. *Plast Reconstr Surg.* 2019;143:1e–9e.
28. Storm-Dickerson T, Sigalove NM. The breast surgeons' approach to mastectomy and prepectoral breast reconstruction. *Gland Surg.* 2019;8:27–35.
29. Maxwell GP, Gabriel A. Bioengineered breast: Concept, technique, and preliminary results. *Plast Reconstr Surg.* 2016;137:415–421.
30. Vaia N, Lo Torto F, Marcasciano M, et al. From the "fat capsule" to the "fat belt": Limiting protective lipofilling on irradiated expanders for breast reconstruction to selective key areas. *Aesthetic Plast Surg.* 2018;42:986–994.
31. Ribuffo D, Atzeni M, Guerra M, et al. Treatment of irradiated expanders: Protective lipofilling allows immediate prosthetic breast reconstruction in the setting of postoperative radiotherapy. *Aesthetic Plast Surg.* 2013;37:1146–1152.
32. Calabrese C, Kothari A, Badylak S, et al. Oncological safety of stromal vascular fraction enriched fat grafting in two-stage breast reconstruction after nipple sparing mastectomy: Long-term results of a prospective study. *Eur Rev Med Pharmacol Sci.* 2018;22:4768–4777.
33. Maruccia M, Elia R, Ciudad P, et al. Postmastectomy upper limb lymphedema: Combined vascularized lymph node transfer and scar release with fat graft expedites surgical and patients' related outcomes. A retrospective comparative study. *J Plast Reconstr Aesthet Surg.* 2019;72:892–901.
34. Khavanin N, Qiu C, Darrach H, et al. Intraoperative perfusion assessment in mastectomy skin flaps: How close are we to preventing complications? *J Reconstr Microsurg.* 2019;35:471–478.
35. Diep GK, Marmor S, Kizy S, et al. The use of indocyanine green angiography in postmastectomy reconstruction: Do outcomes improve over time? *J Plast Reconstr Aesthet Surg.* 2019;72:548–554.

36. Mirhaidari SJ, Beddell GM, Orlando MV, Parker MG, Pedersen JC, Wagner DS. A prospective study of immediate breast reconstruction with laser-assisted indocyanine green angiography. *Plast Reconstr Surg Glob Open* 2018;6:e1774.
37. Salibian AA, Frey JD, Karp NS. Strategies and considerations in selecting between subpectoral and prepectoral breast reconstruction. *Gland Surg*. 2019;8:11–18.
38. Liliav B, Patel P, Jacobson AK. Prepectoral breast reconstruction: A technical algorithm. *Plast Reconstr Surg Glob Open* 2019;7:e2107.
39. Mlodinow AS, Lanier ST, Galiano RD, Kim JYS. Using the Breast Reconstruction Risk Assessment (BRA) score: An individualized risk calculator to assist expectation management and reconstructive decision making in the mastectomy patient. In: Harness J, Willey S, eds. *Operative Approaches to Nipple-Sparing Mastectomy*. Cham, Switzerland: Springer; 2017: 117–126.
40. Casella D, Di Taranto G, Lo Torto F, et al. Body mass index can predict outcomes in direct-to-implant prepectoral breast reconstruction. *Plast Reconstr Surg*. 2020;145:867e–868e.
41. Casella D, Di Taranto G, Onesti MG, Greco M, Ribuffo D. A retrospective comparative analysis of risk factors and outcomes in direct-to-implant and two-stages prepectoral breast reconstruction: BMI and radiotherapy as new selection criteria of patients. *Eur J Surg Oncol*. 2019;45:1357–1363.
42. Komorowska-Timek E, Merrifield B, Turfe Z, Davis AT. Subcutaneous prosthetic breast reconstructions following skin reduction mastectomy. *Plast Reconstr Surg Glob Open* 2019;7:e2078.
43. Srinivasa DR, Holland M, Sbitany H. Optimizing perioperative strategies to maximize success with prepectoral breast reconstruction. *Gland Surg*. 2019;8:19–26.
44. Sigalove S, Maxwell GP, Sigalove NM, et al. Prepectoral implant-based breast reconstruction: Rationale, indications, and preliminary results. *Plast Reconstr Surg*. 2017;139:287–294.
45. Spear SL, Boehmler JH, Bogue DP, Mafi AA. Options in reconstructing the irradiated breast. *Plast Reconstr Surg*. 2008;122:379–388.