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Original Research Article

The PDR-SEQS classification and reconstructive algorithm for breast defects after phyllodes tumor resection: a retrospective cohort study

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ABSTRACT

Background: Phyllodes tumors (PTs) are fibroepithelial neoplasms requiring surgical resection, frequently causing complex reconstructive defects. Currently, no standardized framework exists to guide reconstructive decision-making. This study proposes a novel classification and algorithm based on objective volumetric loss and skin-envelope quality.
Methods: A retrospective cohort study was conducted at a tertiary referral center in the period between June 2020 and December 2024. Adult patients undergoing breast reconstruction following PT resection with a minimum 12-month follow-up were included. Two objective parameters were developed: the phyllodes defect ratio (PDR), quantifying volume loss relative to the contralateral breast, and the skin envelope quality score (SEQS), evaluating residual soft-tissue condition. These metrics informed a five-tier reconstructive decision-making algorithm.
Results: Thirty-five patients met inclusion criteria. Mean PDR and SEQS values were 41.5%±34.3 and 4.8±1.5, respectively. The most prevalent subtype was IIIb (45.7%), followed by II (42.9%). Reconstructive strategies escalated according to algorithm-defined complexity, with autologous reconstruction predominating. Despite extensive defects, definitive reconstruction was achieved in most patients, with infrequent major complications and no compromise of algorithm applicability.
Conclusions: The PDR–SEQS classification provides an objective, clinically applicable framework for managing breast defects following PT resection. By integrating proportional volumetric deficiency and soft-tissue quality, the proposed algorithm standardizes reconstructive decision-making, facilitating reproducible surgical planning from prosthetic to complex autologous approaches. External multicenter validation is warranted.

Keywords: Phyllodes tumor, Breast reconstruction, Reconstructive surgery, Surgical algorithm, Skin envelope, Volumetric assessment

INTRODUCTION

Phyllodes tumors (PTs) are uncommon fibroepithelial neoplasms representing 0.3-1% of all primary breast tumors and less than 3% of fibroepithelial lesions.[1,2] Despite their rarity, their biological behavior—ranging from benign to malignant—and characteristically rapid growth frequently result in massive breast masses prior to diagnosis.[3-5] This rapid expansion causes profound distortion of the native breast anatomy and significant soft-tissue compromise, distinguishing them from standard breast carcinomas.[6,7]

Although complete surgical excision with negative margins remains the oncologic gold standard regardless of histologic subtype, the reconstructive sequelae of these resections are markedly understudied.[8,9] Surgical treatment can yield highly variable defects, ranging from limited partial-volume loss to total breast defects that

necessitate complex reconstruction to restore contour and achieve symmetry with the contralateral breast.[10,11]

Currently, reconstructive planning following PT resection is highly heterogeneous and dictated primarily by surgeon preference or institutional experience rather than objective defect characteristics. While various techniques—ranging from implant-based procedures to microsurgical free tissue transfer—have been described, a standardized reconstructive decision-making algorithm is glaringly absent.[12-14]

From a reconstructive standpoint, successful outcomes hinge on two critical variables: the magnitude of volumetric loss and the viability of the residual skin envelope. To date, no objective parameters exist to quantify these variables and translate them into practical reconstructive recommendations specifically for PT-related defects.

Therefore, the purpose of this study was to develop and apply a novel reconstructive classification based on two objective parameters: the phyllodes defect ratio (PDR), which quantifies post-resection volume loss relative to the contralateral breast, and the Skin envelope quality score (SEQS), which evaluates the condition of the remaining soft tissue. Using a retrospective cohort from a tertiary referral center, we propose a practical clinical framework to standardize decision-making and optimize the selection between prosthetic, autologous, and hybrid reconstruction following PT resection.

METHODS

A retrospective, observational cohort study was conducted at the department of plastic, aesthetic, and reconstructive surgery of the Hospital General de México "Dr. Eduardo Liceaga", a national tertiary referral center for oncologic reconstruction. The institutional prospectively maintained database was queried for consecutive adult patients undergoing breast reconstruction following the surgical resection of a phyllodes tumor between June 2020 and December 2024.

Inclusion criteria

Female patients aged 18 years or older with histopathological confirmation of a benign, borderline, or malignant PT; immediate or delayed breast reconstruction of the post-resection defect; and a minimum postoperative follow-up period of 12 months. Timing of reconstruction was not restricted due to the referral nature and high surgical demand of the institution.

Exclusion criteria

Patients who encompassed incomplete medical records, loss to follow-up prior to 12 months, or patients who declined reconstructive surgery following oncologic resection.

Ethical approval

The study was conducted in accordance with the ethical standards of the 1964 Declaration of Helsinki and its later amendments. Following institutional guidelines for retrospective reviews of de-identified data, the study proceeded in accordance with the policies of the institutional ethics committee. Due to the retrospective nature of the study, the requirement for specific informed consent was waived, though all patients had previously provided standard written consent for surgical procedures and clinical photographic documentation.

Data collection

Demographic, oncologic, reconstructive, and postoperative variables were extracted from electronic and physical medical records. Collected data included age, body mass index (BMI), comorbidities, histopathological subtype, tumor dimensions, type of oncologic resection, and surgical margins. Reconstructive parameters included the timing of reconstruction, specific surgical techniques, operative time, estimated blood loss, postoperative complications, and need for secondary procedures.

Development of PDR

To objectively quantify the magnitude of post-resection volumetric loss, the PDR was developed. Given that PT growth significantly distorts native breast anatomy, the contralateral unaffected breast served as an anatomical baseline surrogate. Volumetric breast and defect volumes were calculated using a simplified anthropometric model based on direct clinical measurements. Specifically, the height, width, and depth (or projection) of both the contralateral breast and the surgical defect were measured intraoperatively and preoperatively using a standard flexible tape measure (Table 1).

The PDR was calculated using the following formula given.

$$PDR\ (\%) = ((Defect\ volume) /(contralateral\ breast\ volume)) \times 100$$

For clinical application, PDR values were stratified into four complexity tiers which are low (<25%), moderate (25–49%), high (50-74%) and critical (>75%).

Development of SEQS

To evaluate the condition of the residual soft-tissue envelope, SEQS was formulated. The SEQS incorporates five variables such as skin integrity, extent of skin resection, anticipated closure tension, skin perfusion and vascularity, and requirement for additional soft-tissue coverage (Table 2).

Each variable was assigned a score from 0 to 2, yielding a total score ranging from 0 to 10. Soft-tissue quality was stratified as adequate (0-2 points), compromised (3-5 points) and insufficient (6-10 points).

PDR–SEQS reconstructive classification and algorithm

By integrating the volumetric loss (PDR) and soft-tissue quality (SEQS), defects were categorized into five reconstructive subtypes which includes type Ia (low PDR with adequate skin envelope), type Ib (moderate PDR with adequate skin envelope), type II (high PDR and/or compromised skin envelope), type IIIa (high PDR with deficient soft-tissue coverage) and type IIIb (critical PDR with insufficient skin envelope) (Table 3). This stratification was subsequently linked to a step-wise decision-making algorithm intended to guide surgical planning across five levels of complexity: simple prosthetic, advanced prosthetic, hybrid, autologous, and complex autologous reconstruction.

Outcomes assessment

The primary outcome was the clinical applicability of the PDR-SEQS framework, defined as the successful execution of the algorithm-guided reconstructive plan. Secondary outcomes included minor complications (e.g., seroma, superficial infection, delayed wound healing) and major complications (e.g., flap loss, implant explantation, reoperation).

Table 1: Phyllodes defect ratio (PDR): calculation methodology and severity.

Calculation parameters			PDR severity	Thresholds
Contralateral breast measurements	**Post-resection defect measurements**	**Formula**	**PDR range**	**Severity**
Height (H)	Height (H)	PDR=defect volume/contralateral breast volume×100	<25%	Low
Width (W)	Width (W)		25–50%	Moderate-low
Depth (D)	Depth (D)		50–75%	Moderate-high
			>75%	High

Table 2: Skin envelope quality score (SEQS): scoring criteria across five cutaneous domains.

Domain	Score 0-favorable	Score 1-compromised	Score 2-severe
Skin integrity	Intact skin	Skin thinning, erythema, or marked distension	Ulceration, necrosis, or tumor exposure
Skin loss/resection	No skin resection	Limited partial skin resection	Extensive skin resection or evident cutaneous defect
Expected closure tension	Tension-free closure	Moderate tension	Closure impossible or severe tension
Skin vascularity/ perfusion	Viable skin with good capillary refill	Questionable perfusion or thinned wound edges	Ischemia, devitalized skin, irradiated tissue, or severe scarring
Need for additional coverage	No additional coverage required	Local advancement flap or limited split-thickness skin graft required	Flap reconstruction or complex coverage required

Table 3: PDR–SEQS classification system: reconstructive subtypes, characteristics, and suggested surgical strategies.

Severity	Subtype	PDR range	SEQS range	Reconstructive characteristics	Suggested reconstruction
Low	**Ia**	<25%	0 – 2	Limited defect with adequate soft-tissue coverage	Simple prosthetic reconstruction
	Ib	25–50%	0 – 2	Significant volume loss with favorable skin envelope	Complex prosthetic reconstruction
Intermed-iate	**II**	50–75%	3 – 5	Major volumetric loss with preserved skin envelope	Advanced prosthetic or hybrid reconstruction
High	**IIIa**	50–75%	6 – 8	Complex defect with compromised skin envelope	Autologous reconstruction
	IIIb	>75%	>8	Massive defect with insufficient cutaneous coverage	Complex autologous reconstruction ± tissue expander ± additional soft-tissue coverage

RESULTS

Patient and oncologic characteristics

A total of 35 patients met the inclusion criteria and were included in the final analysis. The mean age at the time of reconstruction was 47.2±14.2 years (range, 26–68 years). All patients completed the minimum follow-up period of 12 months. Histopathological analysis of the resected specimens demonstrated malignant tumors=15 (42.9%), borderline=11 (31.4%), and benign=9 (25.7%) (Table 4).

Due to the significant dimensions of the tumors at presentation, surgical management frequently necessitated extensive oncologic resections. The surgical procedures performed included skin-sparing mastectomy in 13 patients (37.1%), simple mastectomy in 10 patients (28.6%), partial mastectomy in 7 patients (20.0%), and wide local excision in 5 patients (14.3%).

Table 4: Baseline characteristics, PDR–SEQS classification, and surgical outcomes of the study cohort (n = 35).

Patient and oncologic profile		Defect assessment				Operative data		Complications	
Variable	**N or mean**	**% or SD/ range**	**PDR, % (mean± SD)**	**SEQS (mean± SD)**	**Subtype (N, %)**	**Op. time, min (mean± SD)**	**Blood loss, ml (mean± SD)**	**Minor (N, %)**	**Major (N, %)**
Age, years	47.2	SD±14.2 (26–68)							
Histopathologic diagnosis									
Malignant	15	42.9	48.0±44.9	4.4±1.5	II: 8 (53%), IIIb: 5 (33%)	309±98	541±331	13 (85.7)	8 (53.3)
Borderline	11	31.4	39.5±22.5	5.1±1.5	II: 4 (36%), IIIb: 5 (55%)	297±113	595±291	9 (81.8)	7 (53.5)
Benign	9	25.7	33.1±25.9	4.7±1.7	II: 3 (33%), IIIb: 5 (55%)	291±124	555±285	7 (77.8)	4 (44.4)
Type of resection									
Skin-sparing mastectomy	13	37.1	35.0±21.5	5.1±1.5	—	345±105	622±308	—	—
Simple mastectomy	10	28.50	45.7±29.5	5.0±0.9	—	310±104	762±319	—	—
Partial mastectomy	7	20.0	55.1±51.1	3.7±1.8	—	276±109	554±321	—	—
Wide local excision	5	14.30	30.9±20.7	4.4±1.9	—	204±48	496±141	—	—
Reconstructive timing									
Immediate	16	45.7	45.1±39.0	4.5±1.6	—	312±115	619±30G	—	—
Delayed	19	54.30	38.6±30.1	4.8±1.5	—	293±101	641±298	—	—
PDR-SEQS subtype distribution									
Type Ib (low)	1	2.90	26	2	Ib: 1 (100%)	332	302	1 (100)	1 (100)
Type II (intermediate)	15	42.90	29.2±23.2	3.7±1.0	II: 15 (100%)	284±91	601±305	11 (73.3)	8 (53.3)
Type IIIa (high)	3	8.60	58.9±4.5	6.0±0.0	IIIa: 3 (100%)	365±154	679±412	3 (100)	2 (66.7)
Type IIIb (high)	16	45.70	58.8±42.9	5.5±1.4	IIIb: 16 (100%)	302±118	669±290	13 (81.3)	8 (50)
Overall cohort	35	100	41.5±34.3	4.7±1.5	IIIb: 45.7%; II: 42.9%	Overall cohort	35	100	41.5±34.3

PDR: Phyllodes defect ratio; SEQS: skin envelope quality score; SD, standard deviation. PDR range: 8.0%–183.9%, † Minor complications: epidermolysis (n=11, 31.4%), minor wound dehiscence (n=8, 22.9%), superficial infection (n=7, 20.0%), seroma (n=4, 11.4%). Percentages are non-mutually exclusive, ‡ Major complications: partial flap loss (n=7, 20.0%), reintervention (n=7, 20.0%), partial necrosis (n=5, 14.3%). Cases originally recorded as reintervención reclassified as reintervention.

Application of the PDR–SEQS classification

Application of the proposed parameters revealed a high burden of complex reconstructive defects within the cohort. The mean PDR was 41.5%±34.3, demonstrating extreme variability with values ranging from 2.2% to 183.9%. Evaluation of the residual soft-tissue envelope yielded a mean SEQS of 4.8±1.5.

Following the integration of these variables into the PDR–SEQS classification, the distribution of reconstructive subtypes was type Ia (0 patient (0%)), type Ib (1 patient (2.9%)), type II (15 patients (42.9%)), type IIIa (3 patients (8.6%)) and type IIIb (16 patients (45.7%)). Advanced reconstructive defects, encompassing types II, IIIa, and IIIb, accounted for 97.2% of the study population.

Reconstructive strategies and postoperative outcomes

The surgical strategies utilized were consistent with the complexity stratified by the PDR–SEQS algorithm, demonstrating a progressive escalation in reconstructive complexity as PDR and SEQS values increased.

The most frequently employed reconstructive modalities included acellular dermal matrix (ADM), pedicled latissimus dorsi flaps, implant-based techniques, transverse rectus abdominis myocutaneous (TRAM) flaps, deep inferior epigastric perforator (DIEP) flaps, and adjunctive skin-grafting procedures.

Despite the high prevalence of advanced defects, most patients achieved definitive reconstruction without loss of the reconstructive pathway. Documented minor complications included epidermolysis, donor-site dehiscence, superficial infection, seroma formation, minor implant-related issues, and capsular contracture. Major complications, while present, were infrequent and included flap revision, implant explantation, partial or total flap loss, extensive necrosis, and reoperation. Overall, most complications were successfully managed with secondary procedures, and no significant compromise of the proposed reconstructive algorithm was identified during the follow-up period.

Proposed reconstructive algorithm

Based on the observed relationship between volumetric deficiency, skin-envelope quality, and reconstructive complexity within the study cohort, a stepwise reconstructive algorithm was developed (Figure 1).

The algorithm integrates PDR and SEQS values to stratify defects into five reconstructive subtypes and guide progression from simple prosthetic reconstruction to complex autologous reconstruction according to defect characteristics.

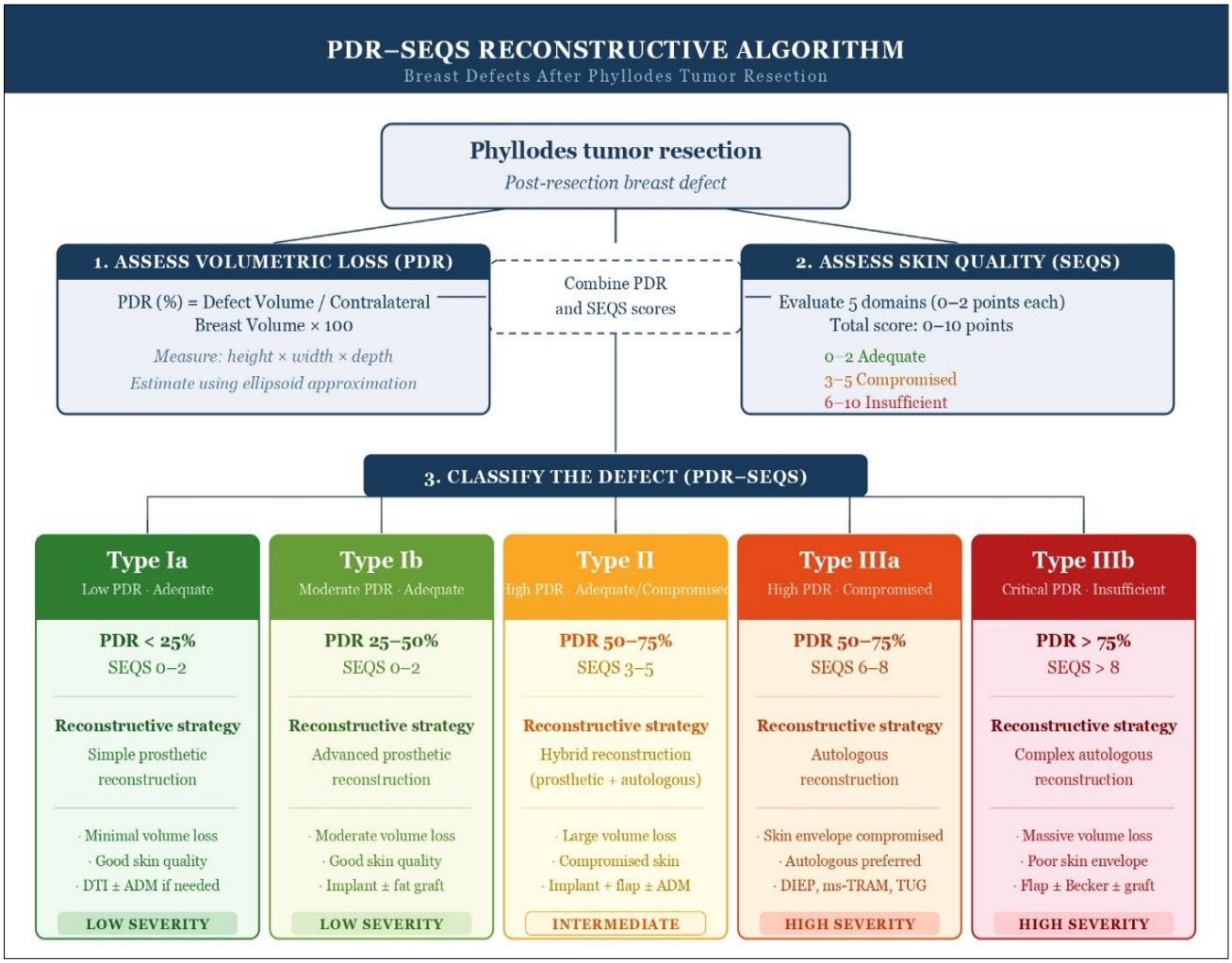

Figure 1: PDR-SEQS reconstructive algorithm.

Application of the PDR-SEQS algorithm in a type IIIb defect.

Figure 2a shows preoperative clinical presentation of a 43-year-old female with a massive, progressively enlarging left breast mass evolving over five years. Severe skin thinning, ulceration, and superficial ischemic changes are evident. Core needle biopsy confirmed a biphasic fibroepithelial lesion consistent with a Phyllodes tumor. Figure 2b shows intraoperative view following left mastectomy. Calculation of the reconstructive parameters demonstrated a PDR of 183.9% and a SEQS of 4, corresponding to a type IIIb defect. Figure 2c shows postoperative outcome following immediate complex autologous reconstruction using a combined approach (pedicled latissimus dorsi flap supplemented with a free deep inferior epigastric perforator [DIEP] flap). This algorithm-guided strategy successfully provided adequate soft-tissue volume and skin coverage, restoring breast contour and symmetry (Figure 2).

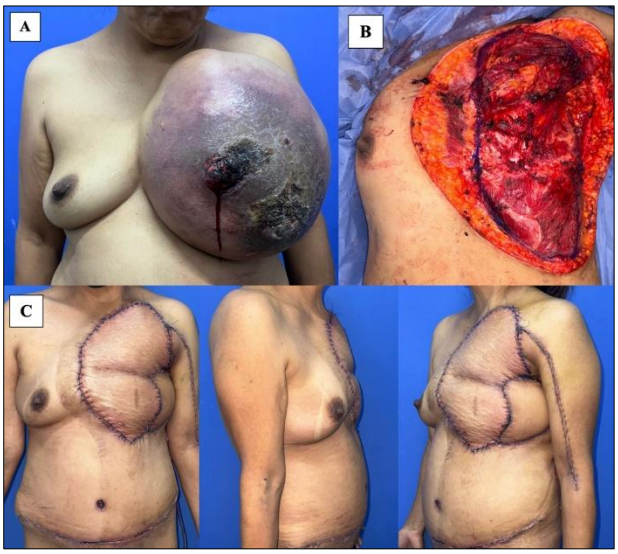

Figure 2: (A) Preoperative image, (B) intraoperative image, and (C) postoperative images of enlarging left breast mass.

DISCUSSION

The present study introduces the PDR–SEQS classification, a novel decision-making framework explicitly designed to address the reconstructive challenges following phyllodes tumor (PT) resection. To our knowledge, this is the first study in the literature to objectively integrate volumetric defect assessment and soft-tissue envelope quality into a unified algorithm to guide surgical planning for this specific oncologic population.

While the oncologic management of PTs—focusing on histopathological grading, recurrence risk, and surgical margins—has been comprehensively described, the reconstructive sequelae have been largely marginalized.[15,16] Existing literature provides minimal guidance on defect management, leaving reconstructive decision-making dependent almost entirely on surgeon preference and institutional experience.[17] The available reconstructive literature following PT resection is largely limited to isolated case reports and small case series describing successful use of specific techniques. Tsuruta et al reported breast reconstruction using a DIEP flap following resection of a giant phyllodes tumor, while Fang et al described reconstruction with a bipedicled DIEP flap in similarly extensive defects.[18,19] Likewise, Tatara et al and Rajesh et al presented individual experiences employing complex autologous reconstruction after radical tumor excision.[17,20] Although these reports demonstrate the feasibility of various reconstructive approaches, they do not provide objective criteria to guide technique selection. Consequently, reconstructive decisions remain largely dependent on surgeon experience, institutional resources, and individual patient characteristics.

A fundamental contribution of this study is the conceptualization of the PDR. Historically, surgical planning has been overly reliant on absolute tumor dimensions. However, absolute tumor size is a poor surrogate for reconstructive requirements, as a 10-cm tumor in a large, ptotic breast creates a profoundly different defect than the same tumor in a small breast.[21] By evaluating the post-resection volume loss relative to the estimated volume of the contralateral breast, the PDR provides a highly individualized and clinically relevant metric of volumetric deficiency.

Equally critical to the algorithm is SEQS. In breast reconstruction, the viability, availability, and vascularity of the residual skin envelope frequently dictate surgical feasibility to a greater extent than mere volume loss.[22] Patients presenting with identical PDRs may necessitate vastly different surgical approaches depending on their SEQS. This score objectively quantifies these soft-tissue limiters, complementing the volumetric assessment to yield a holistic reconstructive picture.

It is imperative to note that the PDR–SEQS classification functions as a heuristic framework rather than a rigid, prescriptive protocol. By stratifying patients according to reconstructive complexity, it guides surgeons toward progressively more advanced strategies without dictating the exact flap or implant type. This structural flexibility ensures the algorithm's adaptability across diverse institutions with varying reconstructive resources and microsurgical expertise.

The disproportionate prevalence of advanced reconstructive defects (types II, IIIa, and IIIb) within our cohort warrants specific consideration. This distribution is heavily influenced by the referral nature of our institution—a national tertiary center that routinely manages neglected, massive, or recurrent tumors demanding radical oncologic clearance and immediate

complex reconstruction. Therefore, the epidemiological distribution of subtypes observed here may not directly extrapolate to community-based centers, where earlier detection likely yields a higher proportion of low-complexity (type Ia and Ib) defects.

This study benefits from several notable strengths. Given the rarity of PTs, our cohort of 35 reconstructed patients represents one of the largest single-institution experiences reported to date. Furthermore, the strict 12-month minimum follow-up ensures a reliable evaluation of intermediate reconstructive outcomes and complications.

Nonetheless, several limitations must be acknowledged. The retrospective design introduces inherent selection and observational biases. The relatively small sample size of low-complexity defects limits robust statistical conclusions regarding these specific sub-cohorts. Most importantly, this classification was developed and applied within a single institution; therefore, external validation remains pending. Future prospective, multicenter studies are essential to validate the PDR–SEQS classification across diverse patient populations, refine its scoring thresholds, and assess its predictive value regarding patient-reported outcomes and long-term satisfaction.

CONCLUSION

Breast reconstruction following the oncologic resection of Phyllodes tumors presents a unique and highly variable clinical challenge, historically lacking a standardized approach. The proposed PDR–SEQS classification provides a novel reconstructive framework by integrating objective assessments of proportional volumetric loss (PDR) and residual skin-envelope quality (SEQS). Application of this framework in a cohort of 35 patients demonstrated high clinical utility, successfully stratifying defect complexity and guiding the selection of prosthetic, hybrid, and autologous strategies across a broad spectrum of challenging clinical scenarios. By shifting the focus from subjective surgeon preference to objective defect characteristics, the PDR–SEQS algorithm provides a reproducible and structured pathway for reconstructive planning. Multicenter validation is warranted to further establish its role in standardizing care for this complex patient population.

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