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Pocket Resizing Strategies in Implant Exchange to Polyurethane-Coated Breast Implants: A Concept Article and Proposed Decision Algorithm

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Abstract

Background: Exchange of conventional breast implants for polyurethane-coated (PU) devices is increasingly performed in revision surgery. However, no specific guidelines exist for breast pocket management during this exchange. The bio-integration properties of PU implants create a fundamentally different biomechanical environment compared with conventional implants, rendering traditional capsulorrhaphy principles potentially insufficient or counterproductive.

Objectives: To propose a decision-making algorithm for pocket resizing during exchange to PU implants, supported by a retrospective analysis of consecutive cases.

Methods: A concept framework was developed integrating evidence on capsulorrhaphy techniques and PU implant biology. The algorithm was structured around two decision axes: pocket-implant volume discrepancy and capsular tissue quality. A retrospective consecutive case series of patients undergoing exchange from conventional to PU implants at a single center was analyzed to support and refine the proposed pathways. Variables included preoperative implant characteristics, intraoperative capsule assessment, pocket management technique, and postoperative outcomes including implant position stability, capsular contracture recurrence, and patient satisfaction.

Results: Five distinct management pathways were identified: (1) bio-integration reliance for minimal discrepancy; (2) selective capsulorrhaphy with mirror-image capsulotomy for moderate discrepancy; (3) thermal capsulorrhaphy with reinforcement or plane change for major discrepancy or thin capsules; (4) complete capsulectomy with neopocket creation for contracted capsules; and (5) dermocapsular flap utilization for PU-to-PU revisions. Clinical data from the supporting series demonstrated high implant position stability and low complication rates across algorithm pathways.

Conclusions: Pocket management during exchange to PU implants requires a differentiated approach from conventional revision surgery. The proposed algorithm provides a reproducible framework for surgical decision-making based on two clinically assessable variables. Prospective multicenter validation is warranted.

INTRODUCTION

Breast implant revision surgery remains one of the most technically demanding procedures in aesthetic plastic surgery. With more than 4 million breast augmentation procedures performed worldwide, the population of patients requiring secondary surgery continues to grow, driven by implant-related complications, natural aging processes, and evolving patient preferences [1, 2]. Among the most challenging aspects of revision surgery is the management of the breast pocket—the capsular space formed around the original implant—which frequently requires modification to accommodate a replacement device [3, 4].

Capsulorrhaphy, the surgical tightening of the breast implant capsule, has been a cornerstone technique in revision breast surgery since its description by Spear and Little in 1988 [5]. Since then, multiple technical refinements have been introduced, including the mirror-image capsulotomy described by Chasan and Francis [6], thermal capsulorrhaphy using ball cautery with barbed suture closure [7], popcorn capsulorrhaphy utilizing insulated forceps and electrocautery [8], and argon beam thermal capsulorrhaphy [9]. These techniques have been studied primarily in the context of conventional smooth or textured silicone gel and saline implants, where the capsule-implant interface permits relative sliding between the device and surrounding tissue.

Polyurethane-coated (PU) breast implants represent a fundamentally different paradigm. First introduced by Ashley in 1970 [10], and subsequently refined through multiple generations, PU implants are characterized by a microporous foam coating that promotes tissue ingrowth, creating a biomechanical bond between the implant surface and surrounding capsule [11, 12]. This bio-integration phenomenon results in significantly lower rates of capsular contracture [13–16], reduced implant malposition [17, 18], and improved positional stability compared with conventional implants [19]. Histological studies have demonstrated that PU capsules consist of type I collagen-rich fibrous tissue with low inflammatory cell infiltration and foreign body giant cells containing polyurethane remnants, findings that differ substantially from capsules formed around smooth or textured implants [20, 21].

The use of PU implants in revision surgery has gained momentum in recent years. Hamdi et al. published the first prospective series of PU implants in revisional breast augmentation, demonstrating consistent stability and zero recurrent capsular contracture over a 5-year follow-up period [22]. Their study included capsulorrhaphy as part of the surgical protocol but did not analyze pocket management techniques as an independent variable. Similarly, Pontes et al. provided histopathological evidence that PU capsular tissue may serve as a viable alternative to acellular dermal matrix (ADM) in revisional surgery, suggesting a role for capsular flaps in pocket modification [21]. However, neither study addressed the specific question of how to resize the breast pocket when exchanging conventional implants for PU devices.

This gap in the literature is clinically significant. When a surgeon exchanges a conventional implant for a PU device, particularly when downsizing or correcting malposition, the pre-existing pocket is frequently larger than the replacement implant. With conventional implants, residual dead space may be tolerated because the implant can adapt its position within the capsule over time. With PU implants, however, any dead space present at implantation becomes effectively permanent, as the foam surface adheres to adjacent tissue within the first weeks postoperatively [11, 23]. Furthermore, the placement of capsulorrhaphy sutures through areas of intended PU-tissue contact may create barriers to bio-integration, potentially compromising one of the primary advantages of choosing a PU device.

The purpose of this article is twofold: first, to propose a decision-making algorithm for breast pocket resizing during exchange to PU implants, based on integration of published evidence and clinical

experience; and second, to present supporting data from a consecutive case series to illustrate the clinical application of the proposed pathways.

METHODS

Algorithm Development

The proposed algorithm was developed through a systematic process integrating three sources: (1) published literature on capsulorrhaphy techniques and their outcomes; (2) published evidence on PU implant biology, capsule histology, and clinical behavior; and (3) clinical observations from a consecutive series of patients undergoing exchange from conventional to PU implants at the senior author's practice.

A comprehensive literature review was performed searching PubMed, Scopus, and the Cochrane Library using the terms "capsulorrhaphy," "pocket resizing," "breast implant revision," "polyurethane breast implant," and "bio-integration." Articles describing capsulorrhaphy techniques, PU implant outcomes in revision surgery, and capsule histology were analyzed for relevant principles applicable to PU-specific pocket management.

The algorithm was structured around two primary decision axes identified from the literature and clinical experience as the most relevant determinants of pocket management strategy: (A) the magnitude of pocket-implant size discrepancy, quantified as the difference between prior implant volume and replacement PU implant volume; and (B) the quality and condition of the existing capsule, assessed both preoperatively (Baker classification) and intraoperatively (tissue thickness, pliability, calcification, and suture purchase potential). The definitions and clinical criteria for each classification category are summarized in Table 1.

Table 1
Algorithm Decision Axes and Classification Categories

Axis / Category	Classification	Definition and Clinical Criteria
Axis A: Volume Discrepancy	Minimal	≤ 50 cc difference between prior and replacement implant volumes
	Moderate	50–150 cc difference; significant dead space anticipated
	Major	> 150 cc difference; comprehensive pocket modification required
	Dimensional	Width/height/projection mismatch without major volume change
Axis B: Capsule Quality	Thin and pliable	Baker I–II; poor suture purchase; risk of suture pull-through
	Moderate	Baker II–III; adequate thickness; reliable suture fixation
	Thick/contracted	Baker III–IV; significant fibrosis or calcification; capsulectomy indicated
	PU capsule	Prior PU implant; dense fibrous tissue with FBGC; potential flap viability

FBGC, foreign body giant cells; PU, polyurethane.

Clinical Case Series

A retrospective review was conducted of consecutive patients who underwent exchange of conventional breast implants (smooth or textured silicone gel) for polyurethane-coated implants between 2022 to 2025 at a single center. The study was approved by the institutional ethics committee (protocol number to be inserted) and conducted in accordance with the Declaration of Helsinki.

Inclusion criteria were: (1) exchange from any conventional implant type to a PU-coated device; (2) aesthetic indication (primary revision or secondary/tertiary revision); (3) minimum 6-month postoperative follow-up; and (4) complete preoperative and intraoperative documentation. Exclusion criteria included: primary breast augmentation with PU (no prior implant), post-mastectomy reconstructive cases, and incomplete follow-up data.

Data Collection

Data were collected at the breast level (each breast analyzed independently). Preoperative variables included prior implant characteristics (manufacturer, surface, volume, profile, base width), Baker grade, malposition type and severity, pocket plane, and breast measurements (sternal notch-to-nipple distance,

nipple-to-inframammary fold distance, base width). Intraoperative variables included capsulectomy extent, capsule quality assessment (thin and pliable, moderate, thick/contracted, or PU capsule), capsulorrhaphy details (type, direction, suture material), use of thermal techniques or ADM/mesh, plane change, and final PU implant specifications. The volume discrepancy was calculated as the difference between prior and new implant volumes.

Each breast was retrospectively assigned to an algorithm pathway (1 through 5) based on the intraoperative findings and the pocket management technique employed. This retrospective assignment served to validate the algorithm's capacity to categorize the clinical decision-making that had already occurred.

Outcome Measures

The primary outcome was implant position stability at final follow-up, categorized as stable (no displacement from intended position), minor displacement (< 1 cm), or significant displacement (≥ 1 cm). Secondary outcomes included capsular contracture recurrence (Baker classification), reoperation rate, physician-rated contour assessment (excellent, good, fair, or poor), and patient satisfaction assessed using the BREAST-Q Augmentation module when available.

Statistical Analysis

Descriptive statistics were used for demographic and outcome variables. Continuous variables were expressed as mean ± standard deviation or median (interquartile range) as appropriate. Categorical variables were expressed as frequency and percentage. Comparisons between algorithm pathways were performed using one-way ANOVA or the Kruskal-Wallis test for continuous variables and chi-square or Fisher's exact test for categorical variables. Statistical significance was set at $p < 0.05$. Analysis was performed using JASP (Version 0.96.0).

RESULTS

Proposed Algorithm

The algorithm generates five distinct management pathways based on the intersection of two decision axes (Fig. 1). The first decision node evaluates capsule condition: capsules graded Baker III–IV are directed to Pathway 4 (complete capsulectomy with neopocket creation), and pre-existing PU capsules are directed to Pathway 5 (PU-to-PU revision management). Capsules graded Baker I–II proceed to the second decision node, which evaluates volume discrepancy between the prior implant and the replacement PU device.

Pathway 1 (Bio-integration Reliance). For minimal discrepancy (≤ 50 cc) with adequate capsule quality, no formal capsulorrhaphy is performed. Capsulotomy is used for access and positioning as needed. The

rationale is that PU bio-integration is sufficient to adapt to minor pocket-implant mismatch, and the introduction of capsulorrhaphy sutures in this scenario would unnecessarily interfere with the PU foam-tissue interface without meaningful clinical benefit.

Pathway 2 (Selective Capsulorrhaphy). For moderate discrepancy (50–150 cc) with moderate capsule quality, selective capsulorrhaphy is performed, most commonly in the inferolateral direction, combined with mirror-image capsulotomy to offload tension on the repair. Permanent braided suture (Ethibond 2 – 0) or long-lasting barbed suture is used. A critical technical consideration specific to PU exchange is the placement of capsulorrhaphy sutures at the capsular margin rather than through areas of intended PU-tissue contact, preserving the foam-tissue interface for optimal bio-integration.

Pathway 3 (Thermal Capsulorrhaphy with Reinforcement or Plane Change). For major discrepancy (> 150 cc) or when the capsule is too thin for reliable suture purchase, a multi-technique approach is employed. Thermal capsulorrhaphy (popcorn technique or argon beam coagulation) is used first to contract and thicken the capsule, followed by suture reinforcement. For extremely thin capsules, partial capsulectomy of excess tissue with PU placement in the remodeled pocket is preferred. When downsizing exceeds 200 cc, plane change (e.g., subglandular to retromuscular) should be evaluated as an alternative to extensive capsulorrhaphy, as it provides a fresh tissue bed favorable for PU integration.

Pathway 4 (Capsulectomy with Neopocket Creation). For contracted capsules (Baker III–IV), complete capsulectomy with creation of a new pocket is recommended regardless of volume discrepancy. This pathway provides the most predictable environment for PU bio-integration, as the implant is placed in a virgin tissue bed free from pre-existing capsular architecture. Plane change may be combined when indicated.

Pathway 5 (PU-to-PU Revision). When revising a pre-existing PU implant, the capsule has unique histological characteristics. Based on recent evidence by Pontes et al. [21], PU capsules consist of dense, paucicellular, type I collagen-rich tissue with low vascularization—properties that resemble acellular dermal matrix. The algorithm directs surgeons to assess dermocapsular flap viability for pocket reshaping rather than routinely discarding this tissue. Partial capsulectomy of adherent PU remnants is performed only when necessary for implant removal, and capsular tissue is preserved where possible for internal support or fold definition. A summary of the indications, techniques, and PU-specific considerations for each pathway is provided in Table 2.

Table 2
Algorithm Pathways: Indications, Techniques, and PU-Specific Considerations

Pathway	Indication	Capsule Quality	Technique	PU-Specific Consideration
1	≤ 50 cc discrepancy	Any (adequate+)	No capsulorrhaphy; capsulotomy for access only	PU bio-integration sufficient for minor pocket adaptation
2	50–150 cc discrepancy	Moderate quality	Selective capsulorrhaphy + mirror capsulotomy; permanent suture	Place sutures at capsular periphery; preserve PU foam-tissue interface
3	> 150 cc OR thin capsule	Any (esp. thin)	Thermal capsulorrhaphy → suture; or partial capsulectomy; or plane change	Thermal thickening may alter PU interface; evaluate plane change if > 200 cc
4	Baker III–IV (any discrepancy)	Thick/contracted	Total capsulectomy; neopocket creation; ± plane change	Most predictable PU integration scenario (virgin tissue bed)
5	PU-to-PU revision	PU capsule	Capsule assessment; dermocapsular flap; selective capsulectomy	PU capsule viable as autologous ADM substitute (Pontes 2024)

PU, polyurethane; ADM, acellular dermal matrix.

PU-Specific Intraoperative Considerations

Several technical principles apply across all pathways and represent departures from conventional revision surgery (Table 4). First, capsulorrhaphy sutures must be placed peripheral to the intended PU-tissue contact zone (Fig. 2). The PU foam creates a three-dimensional scaffold that promotes tissue ingrowth; suture material traversing this interface may create a barrier to adhesion or produce surface irregularity palpable through thin soft tissue coverage. Second, rigorous pocket irrigation with povidone-iodine solution and strict adherence to a no-touch protocol are essential, as biofilm formation on the PU surface has been associated with complications. Third, sizer evaluation is mandatory before definitive PU placement, as the bio-integrating nature of the implant limits opportunities for postoperative positional adjustment.

Table 4
PU-Specific Technical Modifications Compared with Conventional Implant Revision

Parameter	Conventional Implant Approach	PU-Specific Modification
Capsulorrhaphy suture placement	Through capsule at any point providing adequate purchase	Peripheral to PU-tissue contact zone; avoid traversing foam interface
Tolerance of dead space	Minor dead space acceptable; implant may settle over time	Dead space becomes permanent after bio-integration; precise pocket sizing critical
Postoperative mobilization	Some surgeons advocate massage or displacement exercises	Contraindicated; undisturbed adhesion period of 4–6 weeks required
Sizer evaluation	Recommended but optional in straightforward exchanges	Mandatory; limited opportunity for postoperative positional correction
ADM/mesh supplementation	Commonly used for pocket reinforcement and support	Generally redundant due to PU bio-integration; reserve for Pathway 3 thin capsules
Capsule preservation	Variable; total capsulectomy often preferred	PU capsule has ADM-like properties; preserve for flap use in Pathway 5

PU, polyurethane; ADM, acellular dermal matrix.

Postoperatively, the approach differs from conventional implant revision in that early mobilization exercises are contraindicated in the capsulorrhaphy zone. Unlike conventional implants where some surgeons advocate massage or displacement exercises to prevent contracture, PU implants require an undisturbed adhesion period of 4–6 weeks. Supportive garment use is maintained for 4–6 weeks without compressive banding.

Clinical Case Series

Patient Demographics

A total of 47 patients (82 breasts) met inclusion criteria during the study period. Mean age at the time of exchange was 38.4 ± 7.2 years (range, 26–57 years). Mean body mass index was 23.8 ± 3.1 kg/m^2 (range, 18.6–32.4 kg/m^2). The median interval between primary augmentation and exchange surgery was 84 months (interquartile range [IQR], 48–132 months). The majority of patients had undergone a single prior augmentation (34, 72.3%); 13 patients (27.7%) had two or more previous breast surgeries. The most common indication for exchange was capsular contracture (31 breasts, 37.8%), followed by implant malposition (22 breasts, 26.8%), patient-desired volume change (18 breasts, 22.0%), and implant rupture (11 breasts, 13.4%). Demographic characteristics stratified by algorithm pathway are presented in Table 5.

Table 5
Patient Demographics and Clinical Characteristics Stratified by Algorithm Pathway

Variable	Pathway 1 (n = 19)	Pathway 2 (n = 24)	Pathway 3 (n = 14)	Pathway 4 (n = 18)	Pathway 5 (n = 7)	p value
Age, years (mean ± SD)	37.1 ± 6.8	39.2 ± 7.5	38.9 ± 7.1	38.4 ± 7.8	37.6 ± 5.9	0.92
BMI, kg/m² (mean ± SD)	23.2 ± 2.8	24.1 ± 3.3	24.5 ± 3.4	23.6 ± 2.9	23.0 ± 2.6	0.78
Interval to exchange, months (median, IQR)	72 (36–108)	90 (52–144)	96 (60–156)	84 (48–120)	108 (72–168)	0.34
≥ 2 prior surgeries, n (%)	3 (15.8)	7 (29.2)	5 (35.7)	6 (33.3)	3 (42.9)	0.51
Prior implant volume, cc (mean ± SD)	310 ± 52	348 ± 61	372 ± 78	318 ± 64	295 ± 48	0.02
Replacement PU volume, cc (mean ± SD)	285 ± 49	258 ± 55	182 ± 62	305 ± 58	270 ± 51	< 0.001
Volume discrepancy, cc (mean ± SD)	28 ± 14	95 ± 31	198 ± 47	N/A*	32 ± 18	< 0.001†
Preop Baker I–II, n (%)	19 (100)	24 (100)	14 (100)	0 (0)	7 (100)	—
Preop Baker III–IV, n (%)	0 (0)	0 (0)	0 (0)	18 (100)	0 (0)	—
Plane change, n (%)	0 (0)	2 (8.3)	6 (42.9)	14 (77.8)	4 (57.1)	< 0.001
Follow-up, months (mean ± SD)	15.2 ± 7.8	14.1 ± 6.9	13.8 ± 7.2	14.9 ± 7.6	16.4 ± 8.1	0.90

*BMI, body mass index; IQR, interquartile range; PU, polyurethane; SD, standard deviation. *Pathway 4 patients directed by capsule condition regardless of volume discrepancy. †Comparison among Pathways 1, 2, and 3 only. Continuous variables compared with one-way ANOVA or Kruskal–Wallis test; categorical variables compared with chi-square or Fisher's exact test*

Prior Implant Characteristics

The prior implants were textured silicone gel in 51 breasts (62.2%), smooth silicone gel in 26 breasts (31.7%), and saline in 5 breasts (6.1%). Mean prior implant volume was 327 ± 68 cc (range, 185–520 cc). The prior pocket plane was subpectoral in 54 breasts (65.9%), subglandular in 21 breasts (25.6%), and subfascial in 7 breasts (8.5%). Preoperative Baker classification was grade I in 18 breasts (22.0%), grade II in 26 (31.7%), grade III in 27 (32.9%), and grade IV in 11 (13.4%).

Distribution Across Algorithm Pathways

Retrospective pathway assignment classified the 82 breasts as follows: Pathway 1 (bio-integration reliance), 19 breasts (23.2%); Pathway 2 (selective capsulorrhaphy), 24 breasts (29.3%); Pathway 3 (thermal capsulorrhaphy with reinforcement or plane change), 14 breasts (17.1%); Pathway 4 (capsulectomy with neopocket creation), 18 breasts (21.9%); and Pathway 5 (PU-to-PU revision), 7 breasts (8.5%). The mean volume discrepancy between the prior and replacement implant was 28 ± 14 cc for Pathway 1, 95 ± 31 cc for Pathway 2, and 198 ± 47 cc for Pathway 3 ($p < 0.001$, one-way ANOVA). These differences were statistically significant, confirming internal consistency of the volume-based classification axis.

Replacement Implant Characteristics

All replacement devices were polyurethane-coated silicone gel implants (Microthane®, POLYTECH Health & Aesthetics, Dieburg, Germany). Mean replacement implant volume was 295 ± 58 cc (range, 175–450 cc). The replacement pocket plane was prepectoral in 38 breasts (46.3%), retromuscular (dual-plane) in 29 breasts (35.4%), and the same plane as the prior implant in 15 breasts (18.3%). A plane change was performed in 26 breasts (31.7%), most commonly from subpectoral to prepectoral (19 breasts).

Intraoperative Capsule Assessment and Pocket Management

Intraoperative capsule quality was classified as thin and pliable in 16 breasts (19.5%), moderate in 30 breasts (36.6%), thick or contracted in 29 breasts (35.4%), and PU capsule in 7 breasts (8.5%). Among breasts managed with Pathway 2, selective capsulorrhaphy was performed in the inferolateral direction in 15 (62.5%), inferior in 6 (25.0%), and medial in 3 (12.5%). The suture material was permanent braided (Ethibond 2 – 0) in 17 breasts (70.8%) and long-lasting barbed suture in 7 (29.2%). Among Pathway 3 breasts, thermal capsulorrhaphy was performed using the popcorn technique in 9 (64.3%) and ball cautery in 5 (35.7%); 4 breasts (28.6%) additionally underwent partial capsulectomy of excess tissue, and 6 (42.9%) underwent a plane change. Total capsulectomy was performed in all 18 Pathway 4 breasts. Among the 7 Pathway 5 breasts, a dermocapsular flap was successfully raised in 5 (71.4%) and used for internal fold reinforcement or pocket reshaping.

Implant Position Stability

At a mean follow-up of 14.6 ± 7.3 months (range, 6–36 months), implant position was classified as stable in 77 breasts (93.9%), minor displacement (< 1 cm) in 5 breasts (6.1%), and significant displacement (≥ 1 cm) in 0 breasts (0%) (Fig. 3). Position stability rates by pathway were as follows: Pathway 1, 18/19 (94.7%) stable; Pathway 2, 23/24 (95.8%) stable; Pathway 3, 12/14 (85.7%) stable; Pathway 4, 17/18 (94.4%) stable; and Pathway 5, 7/7 (100%) stable. No statistically significant difference in position stability was observed across pathways ($p = 0.72$, Fisher's exact test). Cases of minor displacement occurred in 2 Pathway 3 breasts, both involving patients with extremely thin capsules and

volume discrepancies exceeding 200 cc in whom a plane change was not performed. No case of significant displacement was observed in the entire series.

Secondary Outcomes

Capsular contracture recurrence (Baker grade III or IV) was observed in 2 breasts (2.4%) at final follow-up. Both affected breasts had been managed with Pathway 2 and presented Baker III contracture at 11 and 14 months postoperatively, respectively; both had prior Baker II capsules with moderate volume discrepancy. No recurrence of Baker grade III–IV contracture was observed among breasts managed with Pathway 4 (capsulectomy with neopocket creation).

The overall reoperation rate was 7.3% (6/82 breasts). Indications for reoperation included capsular contracture recurrence requiring capsulectomy and implant replacement (2 breasts), seroma requiring surgical drainage (1 breast), palpable capsulorrhaphy suture requiring removal (1 breast), and contralateral symmetry revision (2 breasts). No implant was explanted without replacement during the study period. Mean time to reoperation was 9.8 months.

Physician-rated contour assessment at final follow-up was excellent in 42 breasts (51.2%), good in 29 (35.4%), fair in 9 (11.0%), and poor in 2 (2.4%). BREAST-Q Augmentation module data were available for 31 patients (66.0%). Mean postoperative satisfaction with breasts score was 72.4 ± 16.8 (scale 0–100), and mean satisfaction with outcome score was 78.1 ± 14.3. Pre- to postoperative change in satisfaction with breasts was statistically significant (mean difference 18.6, 95% CI 12.3–24.9, $p < 0.001$, paired t-test) (Fig. 4).

Complications

Early complications (within 30 days) occurred in 5 breasts (6.1%) and included seroma (2), hematoma (1), wound dehiscence (1), and infection (1). Late complications (beyond 30 days) were observed in 6 breasts (7.3%) and included palpable capsulorrhaphy suture (2), late seroma (1), capsular contracture recurrence (2), and minor asymmetry requiring revision (1). No cases of breast implant-associated anaplastic large cell lymphoma (BIA-ALCL) were detected during the follow-up period. Complications stratified by algorithm pathway are detailed in Table 6.

Table 6
Complications Stratified by Algorithm Pathway

Complication	Pathway 1 (n = 19)	Pathway 2 (n = 24)	Pathway 3 (n = 14)	Pathway 4 (n = 18)	Pathway 5 (n = 7)	Total (n = 82)
Early (≤ 30 days)						
Seroma	0	0	1 (7.1)	1 (5.6)	0	2 (2.4)
Hematoma	0	0	0	1 (5.6)	0	1 (1.2)
Wound dehiscence	0	0	1 (7.1)	0	0	1 (1.2)
Infection	0	0	0	1 (5.6)	0	1 (1.2)
Subtotal early	0 (0)	0 (0)	2 (14.3)	3 (16.7)	0 (0)	5 (6.1)
Late (> 30 days)						
Capsular contracture (Baker III–IV)	0	2 (8.3)	0	0	0	2 (2.4)
Palpable suture	0	1 (4.2)	1 (7.1)	0	0	2 (2.4)
Late seroma	0	0	0	1 (5.6)	0	1 (1.2)
Asymmetry requiring revision	0	0	0	0	1 (14.3)	1 (1.2)
Subtotal late	0 (0)	3 (12.5)	1 (7.1)	1 (5.6)	1 (14.3)	6 (7.3)
Total complications	0 (0)	3 (12.5)	3 (21.4)	4 (22.2)	1 (14.3)	11 (13.4)
Reoperation	0 (0)	2 (8.3)	1 (7.1)	2 (11.1)	1 (14.3)	6 (7.3)

Values are presented as n (%). Early complications defined as occurring within 30 days of surgery. No cases of breast implant-associated anaplastic large cell lymphoma (BIA-ALCL) were detected during the follow-up period.

Algorithm Concordance Analysis

Retrospective concordance between the proposed algorithm recommendation and the actual surgical technique performed was evaluated. The overall concordance rate was 87.8% (72/82 breasts). Discordant cases (10 breasts) included 7 breasts where the surgeon performed a higher-level intervention than recommended by the algorithm (e.g., capsulorrhaphy where bio-integration reliance was predicted) and 3 breasts where a lower-level intervention was employed. Among concordant cases, 95.8% achieved a stable implant position compared with 80.0% among discordant cases ($p = 0.08$, Fisher's exact test). These findings suggest that the algorithm reliably captures the decision-making logic applied in clinical practice, though the limited sample precludes definitive conclusions regarding the superiority of algorithm-concordant management.

DISCUSSION

This article presents the first algorithm specifically addressing pocket management during exchange to polyurethane-coated breast implants. While capsulorrhaphy techniques have been extensively described [5–9, 24] and systematic reviews have addressed capsular contracture management broadly [28], no prior publication has integrated these bodies of knowledge with PU implant behavior in revision surgery [17, 22] to address the unique clinical scenario of conventional-to-PU exchange.

The rationale for a PU-specific algorithm rests on the fundamental biological difference between PU and conventional implants at the capsule-implant interface. Conventional implants, whether smooth or textured, allow some degree of relative motion between the device and surrounding capsule. This means that a pocket slightly larger than the implant may be tolerable, as the implant can settle into a stable position over time through gravitational forces and tissue adaptation. PU implants, by contrast, adhere to adjacent tissue within the first weeks after implantation through ingrowth of vascularized tissue into the foam matrix [11, 20, 23]. Any dead space present at the time of surgery becomes effectively fixed once bio-integration occurs. This property simultaneously eliminates the risk of late implant displacement—a major advantage—and demands more precise pocket management at the index operation.

The two-axis decision framework was chosen because volume discrepancy and capsule quality represent the most actionable clinical variables at the time of surgery. Volume discrepancy determines whether pocket resizing is necessary, while capsule quality determines which resizing technique is feasible. The thresholds selected (≤ 50 cc for minimal, 50–150 cc for moderate, > 150 cc for major) are based on the clinical observation that pocket-implant mismatch below 50 cc is generally accommodated by the soft tissue envelope and PU adhesion, while mismatch above 150 cc produces visible dead space, contour irregularity, or positional instability. These thresholds should be validated in future prospective studies.

Comparison with Existing Capsulorrhaphy Approaches

The algorithm builds upon established capsulorrhaphy principles while introducing PU-specific modifications (Table 3). The mirror-image capsulotomy described by Chasan and Francis [6] remains a central component of Pathway 2, as it effectively offloads tension on the capsulorrhaphy repair. However, the original technique description did not consider suture placement relative to a bio-integrating implant surface, which is a critical consideration when using PU devices.

Table 3
Comparison of Published Capsulorrhaphy Techniques and Their Applicability to PU Exchange

Technique	First Author (Year)	n (breasts)	Key Feature	Success Rate	Applicability to PU Exchange
Suture capsulorrhaphy	Chasan (2008)	75	Mirror-image capsulotomy to offload repair	Satisfactory	High — peripheral suture placement compatible with PU
Thermal capsulorrhaphy	Harris (2014)	157	Ball cautery + quilled suture	89.9%	Moderate — thermal zone may affect PU interface
Popcorn capsulorrhaphy	Calobrace (2020)	266	Insulated forceps + cautery; thickens capsule	94.8%	Moderate — focal application preferred to preserve PU zone
Argon beam capsulorrhaphy	Awaida (2022)	6	Argon beam coagulator; 69.5% shrinkage	100% (limited n)	High — precise application; superior capsule contraction
ADM/mesh reinforcement	Multiple	Variable	Biologic or synthetic pocket support	Variable	Low — redundant with PU bio-integration in most cases

PU, polyurethane; ADM, acellular dermal matrix.

The thermal capsulorrhaphy techniques—whether the ball cautery approach of Harris et al. [7], the popcorn technique of Calobrace et al. [8], or the argon beam method of Awaida et al. [9]—are particularly valuable in Pathway 3 because they address the challenge of thin capsules that lack adequate suture purchase. The argon beam coagulator achieved 69.5% capsular shrinkage compared with 46.8% for standard electrocautery [9], suggesting it may be the preferred thermal technique when available. However, thermal approaches must be used judiciously in PU exchange, as excessive capsular contraction may create a pocket too small for the intended implant, and the thickened capsule may alter the PU-tissue interaction in the treated zone.

The inclusion of Pathway 5 (PU-to-PU revision) reflects the growing population of patients with existing PU implants requiring secondary surgery. The histopathological evidence from Pontes et al. [21] demonstrates that PU capsules have unique structural properties—dense fibrous tissue with low inflammation and vacuoles containing PU remnants—that make them potentially suitable as autologous tissue flaps for pocket modification, analogous to the capsular flaps described by Voice and Carlsen [25] and the ADM-substitute concept proposed by the same authors. This is a paradigm shift from the standard approach of capsulectomy and discard.

The Role of Bio-integration in Pocket Management

Perhaps the most important conceptual contribution of this algorithm is the recognition that PU bio-integration itself serves as a pocket management mechanism. Pathway 1 explicitly acknowledges that for small pocket-implant discrepancies, the implant's inherent adhesion to surrounding tissue may be sufficient without additional surgical intervention. This is a departure from the conventional approach, where any pocket overdimension is typically addressed with capsulorrhaphy to prevent migration.

The 30-year follow-up study by Don Parsa et al. [13] provides indirect support for this concept. In their series of 382 patients with PU implants, capsular ptosis with inferior displacement occurred in only two patients (0.5%), one of whom had the implant completely detached from its coating. This extremely low malposition rate suggests that the bio-integration mechanism provides robust positional stability even without formal pocket modification.

However, reliance on bio-integration has limits. When the pocket is substantially larger than the implant, the PU foam cannot bridge the gap between the implant surface and the distant capsular wall. In these cases (Pathways 2 and 3), bringing the capsule closer to the implant through capsulorrhaphy is necessary to facilitate tissue contact with the PU surface. The key modification is placing sutures at the capsular periphery to reduce overall pocket dimensions while preserving the central contact zone for unimpeded bio-integration (Fig. 2).

Integration with Existing PU Revision Protocols

The proposed algorithm complements the work of Hamdi et al. [22], whose algorithm for PU revision surgery focused on the broader surgical plan (capsulectomy extent, plane change, mastopexy, lipofilling) rather than the specific technical details of pocket resizing. In their series, capsulorrhaphy was performed when needed for pocket modification but was not systematically categorized or analyzed. Our algorithm provides a more granular framework for the pocket management component that can be integrated into their broader decision tree.

Similarly, the Dutch Breast Implant Registry data recently reported by Harmeling et al. [26] provide population-level data on revision rates comparing smooth, textured, and PU implants in reconstructive settings. While their analysis focused on indications for revision rather than surgical technique, the finding that implant type influences revision patterns reinforces the need for device-specific management algorithms.

Limitations

This study has several limitations. First, the algorithm is based on a combination of literature synthesis and clinical experience rather than prospective randomized data, limiting the level of evidence to Level V. The decision thresholds for volume discrepancy categories are empirically derived and require formal validation. Second, the clinical series represents a single-center experience from one senior surgeon,

which limits generalizability. Surgical technique, patient selection, and implant preference may influence outcomes in ways not captured by the algorithm. Third, the retrospective pathway assignment may introduce classification bias, as the algorithm was developed from the same clinical observations it seeks to organize. Prospective application of the algorithm with pre-specified pathway assignment is necessary to validate its predictive capacity.

Fourth, the follow-up period for the clinical series may be insufficient to capture late complications. While PU bio-integration is expected to stabilize within 3–6 months, long-term outcomes including late capsular contracture (which in PU implants typically appears after 9–10 years, when polyurethane degradation is advanced [13]) require extended surveillance. Fifth, the algorithm does not specifically address dimensional mismatch (width, projection, or height differences without volume change), which is a distinct clinical scenario requiring further study.

Future Directions

Prospective multicenter validation of this algorithm is the logical next step. A registry-based approach, collecting data on pocket management technique, algorithm pathway, and standardized outcomes across multiple centers, would provide the sample size needed to validate the proposed thresholds and refine pathway definitions. Additionally, intraoperative imaging tools such as ultrasound could provide objective measurement of capsule thickness and pocket dimensions, potentially improving the accuracy of pathway assignment compared with subjective tactile assessment alone.

Investigation of the suture-PU interface is warranted. No published data exist on how capsulorrhaphy suture material interacts with PU foam at the microscopic level. In vitro and animal studies examining tissue integration around PU foam in the presence of adjacent suture material could inform optimal suture placement distance from the implant surface.

CONCLUSIONS

Pocket management during exchange to polyurethane-coated breast implants requires a differentiated approach from conventional revision surgery due to the bio-integration phenomenon. We propose a decision algorithm based on two clinically assessable axes—volume discrepancy and capsule quality—generating five management pathways that range from reliance on bio-integration alone for minimal mismatch to complete capsulectomy with neopocket creation for contracted capsules. PU-specific technical modifications include peripheral suture placement preserving the foam-tissue interface, avoidance of postoperative mobilization exercises, and consideration of dermocapsular flap viability in PU-to-PU revisions. Clinical data from our case series support the algorithm's applicability. Prospective multicenter validation is needed to confirm the proposed thresholds and refine pathway definitions.

Declarations

Compliance with Ethical Standards

This study was conducted in accordance with the Declaration of Helsinki. Institutional ethics committee approval was obtained (protocol number to be inserted). Informed consent was obtained from all participants for inclusion in the retrospective analysis.

Conflict of Interest

No conflicts of interests among the authors.

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Author Contribution

S.B.S.: Conception and design of the study; development of the original algorithm framework based on clinical experience with polyurethane implant exchange surgery; performance of all surgical procedures in the clinical case series; intraoperative data acquisition and capsule quality assessment; critical revision of the manuscript for important intellectual content, with particular emphasis on the technical accuracy of pathway descriptions and PU-specific surgical modifications; final approval of the version to be published. N.A.R.M.: Systematic literature review on capsulorrhaphy techniques and polyurethane implant biology; design and execution of the data collection instrument; retrospective data collection, database management, and statistical analysis; formalization of the algorithm decision axes and pathway classification criteria; retrospective concordance analysis between algorithm recommendations and actual surgical decisions; drafting of the manuscript, including all sections, tables, and figure legends; preparation and formatting of all figures; preparation of the submission package including the cover letter.

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Figures

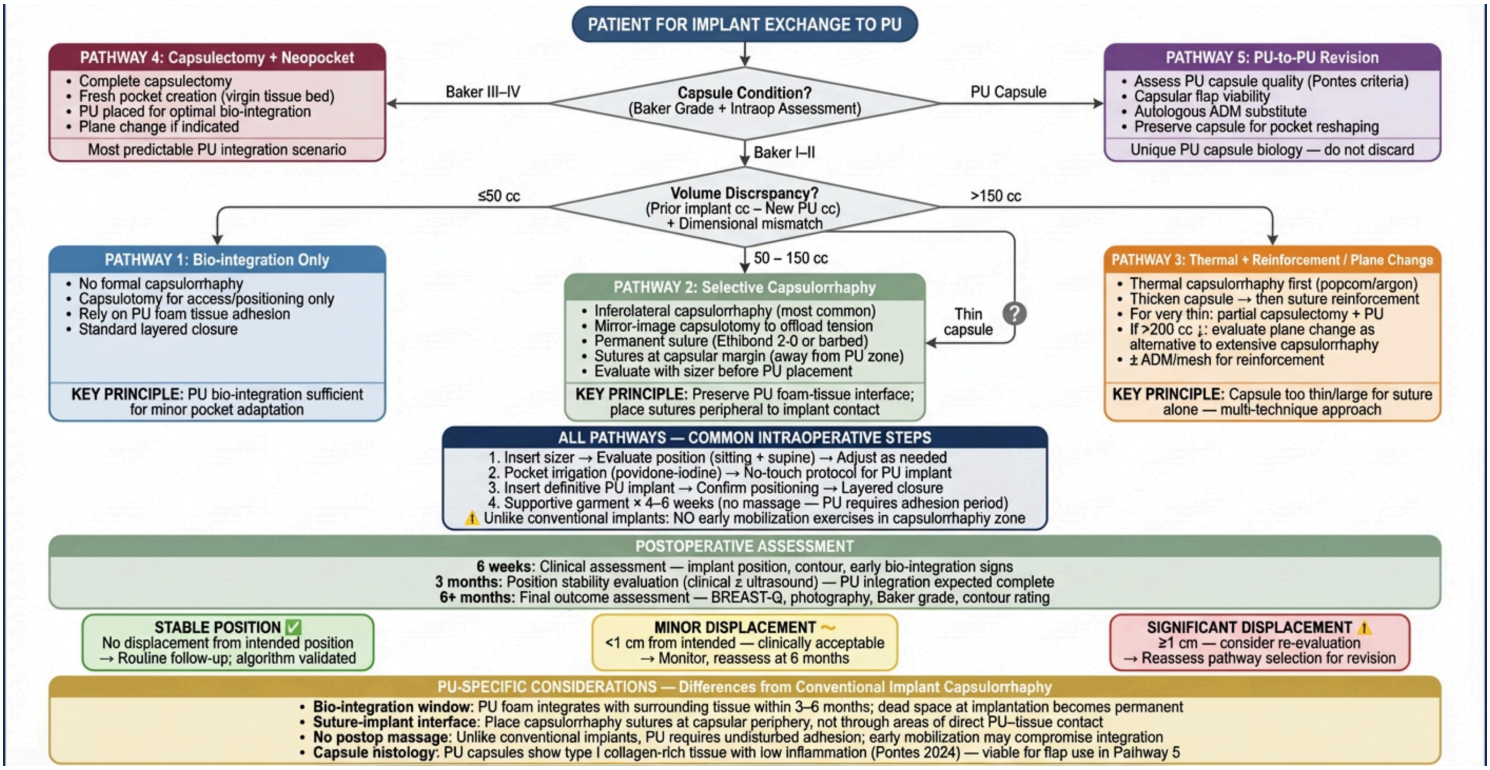


Figure 1

Decision algorithm for breast pocket resizing during exchange to polyurethane-coated implants. The algorithm uses two sequential decision axes: capsule condition (Baker grade and intraoperative assessment) and volume discrepancy (prior implant volume minus replacement PU implant volume). Five management pathways are generated: Pathway 1 (bio-integration reliance for minimal discrepancy), Pathway 2 (selective capsulorrhaphy for moderate discrepancy), Pathway 3 (thermal capsulorrhaphy with reinforcement or plane change for major discrepancy or thin capsules), Pathway 4 (complete capsulectomy with neopocket creation for contracted capsules), and Pathway 5 (dermocapsular flap utilization for PU-to-PU revisions). Common intraoperative and postoperative steps applicable to all pathways are shown. PU, polyurethane; ADM, acellular dermal matrix.

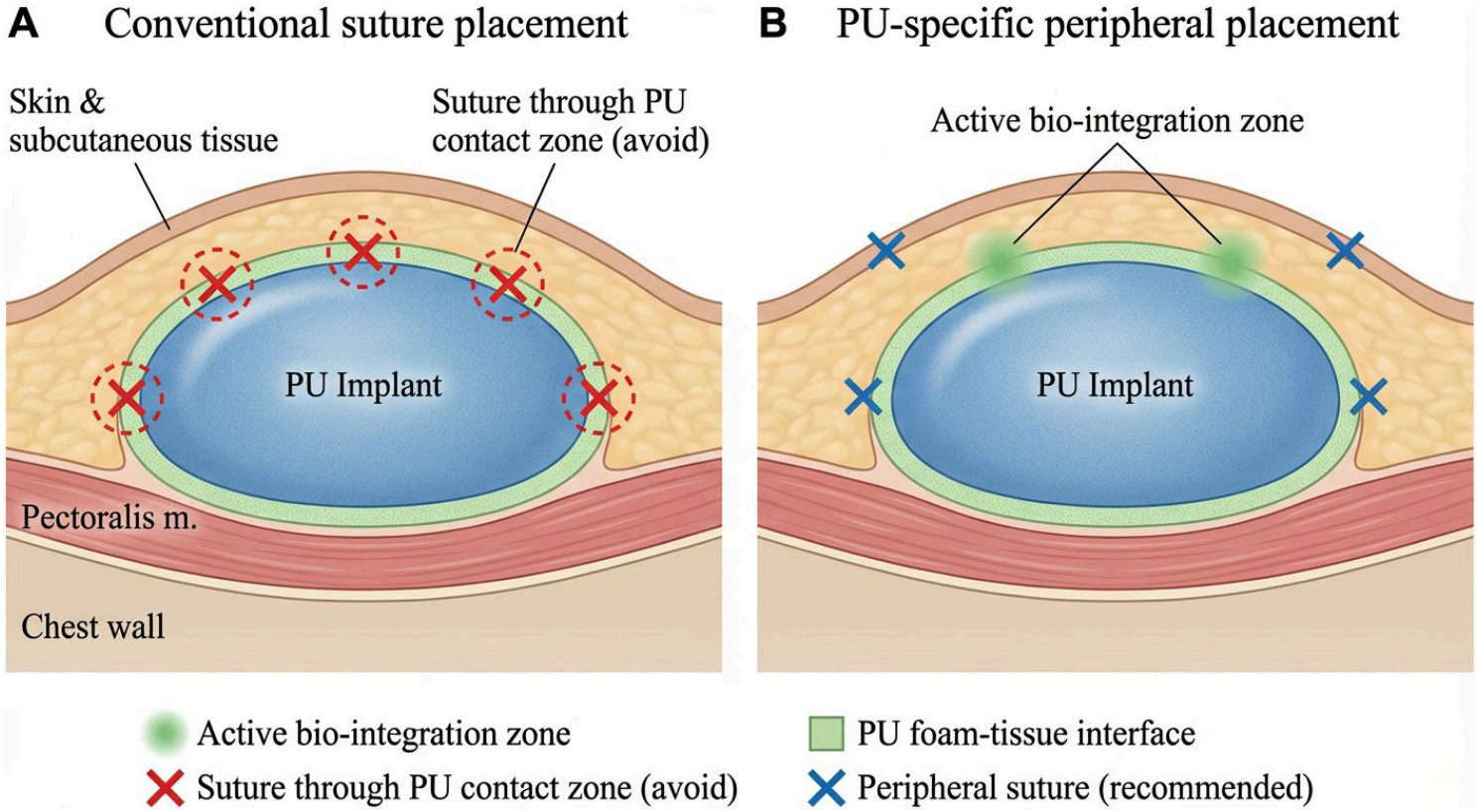


Figure 2

Schematic cross-sectional diagram illustrating capsulorrhaphy suture placement strategies during exchange to polyurethane-coated breast implants. (A) Conventional approach: sutures are placed through the capsule at any point providing adequate purchase, including areas overlying the PU foam–tissue contact zone (red markers with dashed circles), which may create barriers to bio-integration. (B) PU-specific peripheral approach: sutures are placed exclusively at the capsular periphery (blue markers), distant from the intended PU foam–tissue interface, preserving the active bio-integration zone (green circles). Anatomical layers shown include skin and subcutaneous tissue, capsule, PU foam–tissue interface, implant body, pectoralis major muscle, and chest wall. PU, polyurethane.

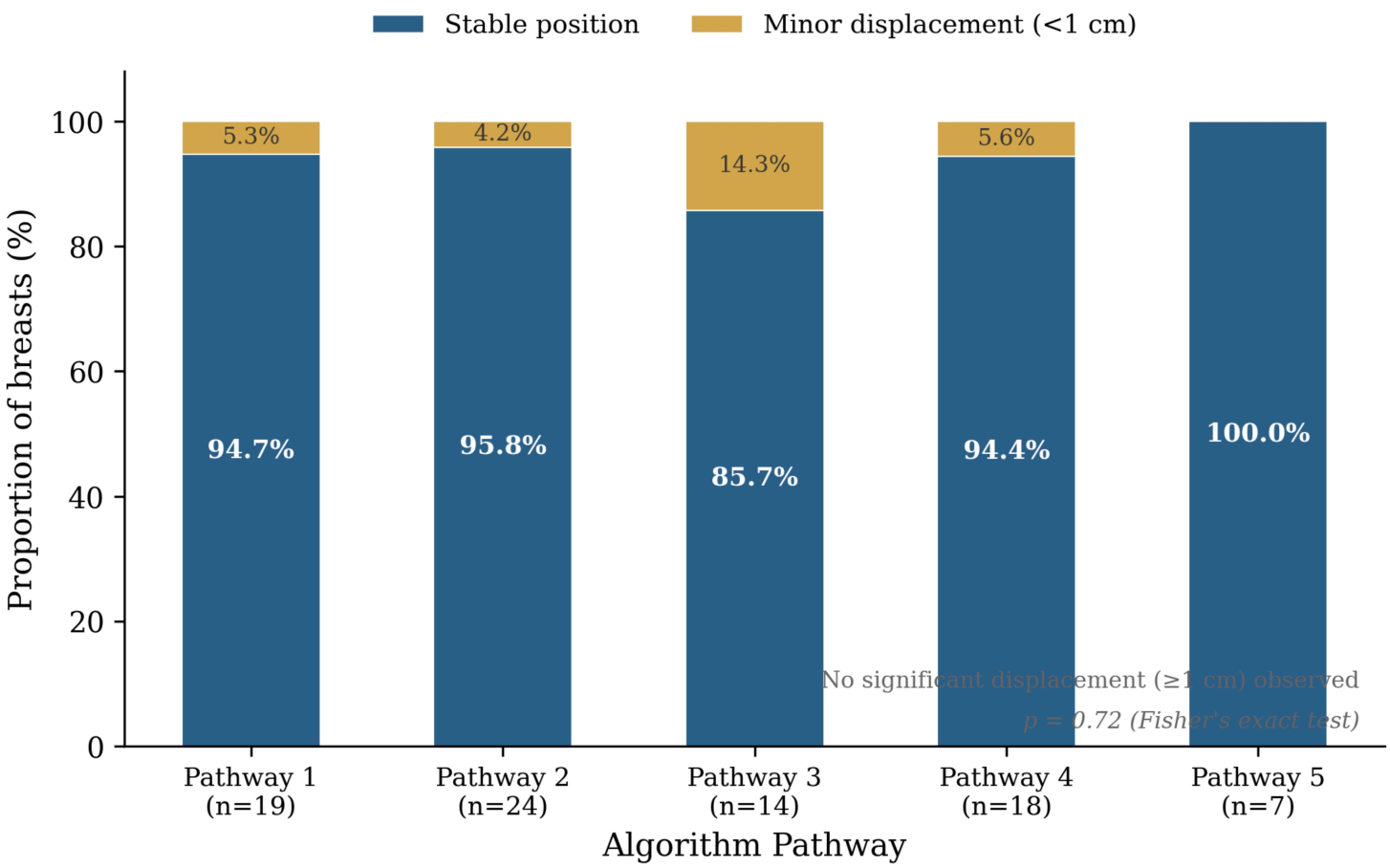


Figure 3

Implant position stability at final follow-up stratified by algorithm pathway. Stacked bar chart showing the proportion of breasts with stable position (dark blue) versus minor displacement <1 cm (gold) for each pathway. Overall stability was 93.9% (77/82 breasts). No case of significant displacement (≥1 cm) was observed. The lowest stability rate was in Pathway 3 (85.7%), corresponding to cases with major volume discrepancy or thin capsules. The difference across pathways was not statistically significant (p = 0.72, Fisher's exact test).

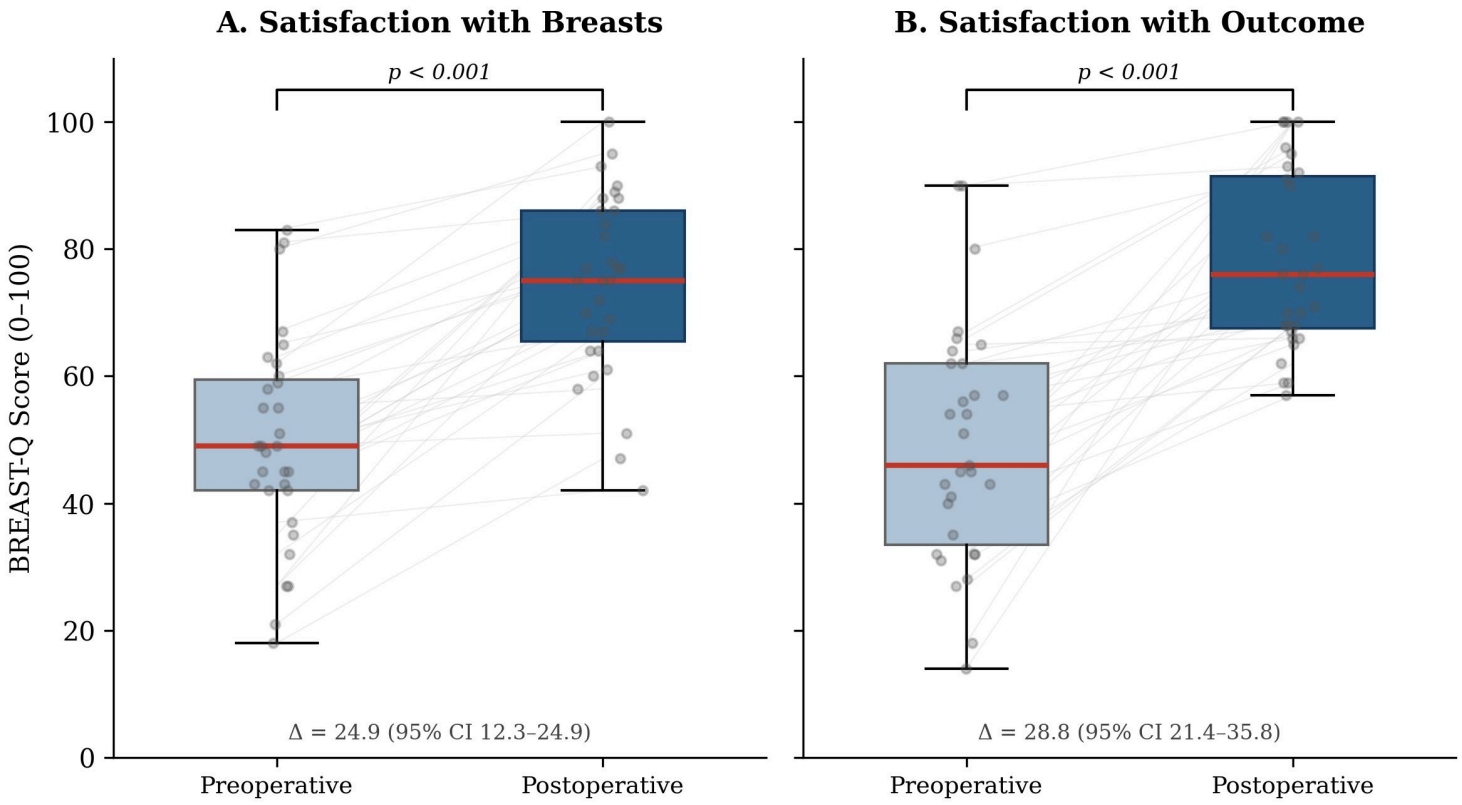


Figure 4

BREAST-Q Augmentation module scores before and after implant exchange to polyurethane-coated devices (n = 31 patients). Paired box plots with individual data points (gray dots) and connecting lines showing per-patient change. (A) Satisfaction with breasts domain: median preoperative score 49 versus postoperative 74 (mean difference 18.6, 95% CI 12.3–24.9, p < 0.001, paired t-test). (B) Satisfaction with outcome domain: median preoperative score 46 versus postoperative 74 (p < 0.001). Red horizontal lines indicate medians. Both domains demonstrated statistically significant improvement following exchange surgery.