

Review

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Review

Personalized Breast Reconstruction After Breast-Conserving Therapy: Risk-Stratified Approaches to Technique Selection and Timing

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Abstract

Breast-conserving therapy (BCT), consisting of lumpectomy followed by adjuvant radiation, provides oncologic outcomes equivalent to mastectomy for many patients with breast cancer. As survivorship increases, the demand for aesthetic restoration after BCT has grown; however, reconstructive strategies in this setting remain less standardized than those following mastectomy. Reconstruction after BCT presents distinct challenges due to partial tissue loss, nonuniform radiation injury, progressive fibrosis, and wide variability in patient expectations and tolerance for revision surgery. Consequently, mastectomy-based reconstructive algorithms are often insufficient for guiding care in this population. This review synthesizes contemporary reconstructive options following BCT through a personalized medicine framework, emphasizing patient-specific risk factors that influence technique selection, timing, and long-term outcomes. Key determinants include radiation exposure, breast morphology, comorbid conditions, prior breast surgery, and psychosocial preferences. Oncoplastic volume displacement, implant-based augmentation, fat grafting, and autologous reconstruction each demonstrate distinct risk profiles in the post-BCT tissue environment and require individualized application. Timing of reconstruction and willingness to undergo staged procedures play a central role in outcome durability and patient satisfaction. Across reconstructive strategies, revision burden emerges as a clinically meaningful, patient-centered outcome that is not adequately captured by traditional short-term complication metrics. A risk-stratified approach that integrates individualized risk assessment with transparent counseling and shared decision-making may improve alignment between reconstructive planning and patient goals. Personalized reconstruction after BCT requires moving beyond technique-driven paradigms toward flexible, longitudinal care pathways. Future efforts should focus on developing BCT-specific predictive models and incorporating patient-reported outcomes to advance personalized reconstructive care.

Keywords: breast conserving therapy; breast reconstruction; patient reported outcomes; aesthetic; personalized medicine

Introduction

Breast-conserving therapy (BCT), consisting of lumpectomy followed by adjuvant radiation, has become a cornerstone of contemporary breast cancer management, offering oncologic outcomes equivalent to mastectomy for appropriately selected patients while preserving native breast tissue [1,2]. As long-term survival has improved, increasing attention has been directed toward the aesthetic and psychosocial sequelae of BCT [3–6]. Despite the widespread adoption of breast conservation, reconstructive strategies for patients who experience contour deformity, volume asymmetry, or radiation-induced tissue changes after lumpectomy remain far less standardized than those following mastectomy [7].

Reconstruction after BCT presents a distinct clinical challenge that differs fundamentally from post-mastectomy reconstruction. Unlike mastectomy patients, individuals treated with lumpectomy retain variable amounts of breast tissue that have often been exposed to nonuniform radiation fields, resulting in fibrosis, volume contraction, and compromised vascularity. These changes create a heterogeneous tissue environment in which reconstructive outcomes are less predictable, and complication profiles vary widely [8,9]. Moreover, reconstructive interventions in this setting must account for ongoing oncologic surveillance, patient tolerance for asymmetry or staged procedures, and the cumulative burden of revision surgery over time [10].

Current reconstructive paradigms are largely derived from mastectomy-based algorithms and are frequently applied to BCT patients without sufficient consideration of their unique risk profiles. Implant-based and fat grafting techniques following lumpectomy are often discussed in isolation, with limited integration of patient-specific factors such as radiation exposure, breast morphology, comorbidities, and prior surgical history [11–13]. As a result, counseling may inadequately reflect the true likelihood of complications, revision procedures, or delayed aesthetic dissatisfaction in this population.

Personalized medicine offers a framework through which reconstruction after BCT can be more effectively tailored to the individual patient. Rather than emphasizing a single “best” reconstructive approach, personalization prioritizes risk stratification, patient preferences, and contextual decision-making to guide technique selection and timing. In this model, outcomes such as revision burden, durability of aesthetic results, and patient-reported satisfaction become central metrics of success, complementing traditional complication rates.

This review aims to synthesize the existing literature on reconstructive options following breast-conserving therapy through a personalized medicine lens. We focus on patient-specific risk factors that influence reconstructive outcomes, examine how these risks intersect with available reconstructive techniques, and propose a risk-stratified framework to guide individualized decision-making. By integrating oncologic considerations, tissue characteristics, and patient goals, this review seeks to provide a practical and personalized approach to reconstruction after BCT that better aligns surgical planning with long-term outcomes and patient expectations.

Unique Challenges After Breast-Conserving Therapy

Reconstruction following breast-conserving therapy (BCT) occurs within a biologically and anatomically altered tissue environment that differs substantially from that encountered after mastectomy. The combination of partial tissue excision and adjuvant radiation produces variable changes in breast volume, contour, and skin quality, resulting in reconstructive challenges that can be underestimated [14,15]. Unlike mastectomy reconstruction, where the surgical field is relatively uniform and reconstruction replaces the entirety of the breast mound, post-BCT reconstruction must integrate new volume or contour correction into a variably asymmetric and potentially fibrotic, scarred breast.

Altered Tissue Biology After Lumpectomy and Radiation

Lumpectomy creates a localized volume deficit that may evolve over time as postoperative changes and radiation effects progress. Adjuvant radiation further compounds these changes by inducing fibrosis, microvascular injury, and chronic inflammation, leading to progressive tissue stiffening, skin thickening, and volume contraction [16]. Importantly, radiation fields following lumpectomy are often nonuniform, resulting in asymmetric tissue injury that can affect reconstructive predictability. This heterogeneity in tissue quality increases the risk of wound healing complications, fat necrosis, capsular contracture, and suboptimal aesthetic outcomes, particularly when implant-based or volume replacement techniques are employed [17,18].

The temporal nature of radiation-induced changes adds another layer of complexity. Tissue characteristics may continue to evolve for years after treatment, meaning that reconstructive outcomes achieved early may not be durable over time [19]. This dynamic process complicates both

surgical planning and patient counseling, as the final aesthetic result may not stabilize until long after reconstruction has been completed.

Oncologic and Surveillance Considerations

Reconstructive decision-making after BCT must also remain closely aligned with oncologic priorities. Margin status, tumor biology, and the need for ongoing surveillance imaging can influence both the timing and type of reconstruction offered [14]. Concerns regarding interference with mammographic or magnetic resonance imaging surveillance persist, particularly with implant-based augmentation or extensive fat grafting. While contemporary imaging techniques have largely mitigated these issues, lingering uncertainty may influence patient and provider comfort with certain reconstructive approaches [20,21].

Additionally, reconstructive interventions following BCT must account for the possibility of future oncologic events, including ipsilateral recurrence or the need for completion mastectomy [22]. Reconstructive strategies that limit future options or increase surgical complexity in the event of recurrence may not be appropriate for all patients, underscoring the importance of individualized risk assessment [14].

Aesthetic Expectations and Asymmetry Tolerance

Patients undergoing reconstruction after BCT often seek restoration rather than replacement of the breast, with expectations that their postoperative appearance will approximate their pre-treatment baseline. However, tolerance for residual asymmetry varies widely and is influenced by breast size, pre-existing asymmetry, clothing preferences, and psychosocial factors [23]. Unlike mastectomy reconstruction, where bilateral symmetry can often be addressed concurrently, post-BCT reconstruction may require contralateral surgery, staged procedures, or acceptance of persistent asymmetry.

These considerations make reconstruction after BCT particularly sensitive to patient expectations and risk tolerance. Some patients may prioritize minimal intervention and accept modest asymmetry, while others may pursue multiple revision procedures to achieve a desired aesthetic outcome. Failure to align reconstructive strategy with these individualized preferences can lead to dissatisfaction even in the absence of surgical complications, highlighting the vitality of appropriate preoperative counseling [24].

Revision Burden as a Distinct Outcome Metric

A defining feature of reconstruction after BCT is the cumulative burden of revision surgery [8]. Many reconstructive approaches in this setting, particularly fat grafting and implant augmentation, are inherently staged and may require multiple procedures to achieve or maintain acceptable outcomes. Radiation-related changes, delayed volume loss, and progressive fibrosis further contribute to the need for secondary interventions [25].

Traditional outcome reporting, which often focuses on short-term complication rates, inadequately captures this longitudinal experience [26,27]. For BCT patients, revision burden represents a clinically meaningful and patient-centered outcome that must be incorporated into reconstructive planning and counseling [8,23]. Recognizing revision likelihood as a function of patient-specific risk factors provides a foundation for a more personalized and transparent approach to reconstruction.

Patient Factors Driving Personalized Reconstruction After Breast Conserving Therapy

Reconstruction following breast-conserving therapy (BCT) is uniquely sensitive to patient-level variability (Table 1). Unlike mastectomy reconstruction, where standardized pathways can often be applied, outcomes after BCT are heavily influenced by a constellation of demographic, treatment-

related, anatomic, and psychosocial factors [3,28–30]. Appreciating how these variables interact is essential for tailoring reconstructive strategy, counseling patients effectively, and anticipating both complications and revision burden.

Table 1. Patient-level variables that influence reconstructive strategy, timing, and anticipated revision burden following breast-conserving therapy.

| Risk Factor Category | Specific Factors | Reconstructive Implications |
|-----------------------------|--|--|
| Demographic | Age, BMI, smoking status | Influences wound healing, tolerance for staged reconstruction, revision risk |
| Medical comorbidities | Diabetes, connective tissue disease | Increased complication risk in irradiated tissue |
| Treatment-related | Radiation dose/field, chemotherapy | Drives fibrosis, volume loss, capsular contracture risk |
| Breast morphology | Breast size, ptosis, baseline asymmetry | Determines feasibility of volume displacement vs replacement |
| Tumor characteristics | Location, size, margin status | Affects defect visibility and reconstructive options |
| Prior breast surgery | Augmentation, reduction, mastopexy | Alters tissue planes and implant-related risk |
| Psychosocial factors | Aesthetic priorities, revision tolerance | Critical determinant of satisfaction |

Demographic and Medical Factors

Patient comorbidities play a central role in determining reconstructive risk after BCT, particularly in the setting of irradiated tissue. Elevated body mass index, smoking history, diabetes, and connective tissue disease have all been associated with impaired wound healing, increased rates of infection, and compromised aesthetic outcomes [29,31–34]. In the post-BCT population, these risks are amplified by radiation-induced microvascular injury and fibrosis, which limit tissue reserve and reduce tolerance for additional surgical insult [35–38]. Age may also influence reconstructive decision-making, not only through physiologic considerations but through differences in aesthetic priorities, willingness to undergo staged procedures, and tolerance for asymmetry [39,40]. Importantly, these demographic factors rarely operate in isolation; rather, they compound one another, underscoring the need for holistic risk assessment rather than single-variable exclusion criteria [41].

Treatment-Related Factors

Among all patient-specific variables, prior radiation exposure exerts the most profound and consistent influence on reconstructive outcomes after BCT [42]. Radiation dose, fractionation, and field geometry affect both the severity and distribution of tissue injury [43,44]. Nonuniform radiation fields following lumpectomy create asymmetric patterns of fibrosis and volume loss that complicate reconstruction and reduce predictability, particularly for implant-based approaches [45]. The timing of reconstruction relative to radiation is another critical determinant of risk. Early intervention may occur before radiation effects have fully declared themselves, whereas delayed reconstruction must contend with established fibrosis and tissue contraction [45,46]. Chemotherapy, particularly when administered concurrently or sequentially with radiation, may further impair wound healing and influence the optimal timing of reconstruction [47,48]. These factors highlight the importance of individualized timing decisions rather than strict adherence to dogma.

Breast-Specific and Anatomic Factors

Breast morphology strongly influences reconstructive options after BCT. Breast size, degree of ptosis, and baseline asymmetry affect the feasibility of volume displacement techniques and the likelihood that contralateral symmetrization will be required [15,28,49,50]. Smaller breasts with limited tissue redundancy may be less forgiving of lumpectomy-related volume loss and may necessitate volume replacement strategies, whereas larger breasts may better accommodate oncoplastic rearrangement [17].

Tumor location also has important reconstructive implications. Defects in the lower pole or central breast often produce more visible deformities and are less amenable to simple rearrangement, while upper pole defects may be more easily concealed [29,51]. Prior breast surgery, including augmentation or reduction, introduces additional complexity by altering tissue planes, vascularity, and implant–tissue interactions [52]. Patients with pre-existing implants represent a distinct subgroup in whom implant-based augmentation after lumpectomy may be appealing but carries unique risks related to capsular contracture and implant malposition in the setting of radiation [53].

Patient Preferences and Psychosocial Factors

Personalized reconstruction after BCT must extend beyond physiologic risk to encompass patient values, expectations, and tolerance for trade-offs. Patients vary widely in their willingness to undergo staged procedures, accept temporary or permanent asymmetry, or assume the risks associated with implants or fat grafting [54]. Some prioritize minimal intervention and rapid recovery, while others are motivated to pursue multiple revisions to achieve a specific aesthetic outcome. Psychosocial context, including body image, professional and lifestyle demands, and prior experiences with cancer treatment, shapes these preferences and influences satisfaction independently of objective surgical outcomes [55–57]. Failure to account for these factors can result in discordance between surgeon-defined success and patient-reported satisfaction.

A critical but underappreciated dimension of risk after BCT reconstruction is the cumulative burden of revision surgery [27]. Many reconstructive strategies in this setting are inherently iterative, with outcomes evolving over time as radiation effects progress and tissue characteristics change [8,19]. Fat grafting often requires multiple sessions, while implant-based augmentation may necessitate revisions for capsular contracture, asymmetry, or contour deformity [58,59]. Traditional complication metrics fail to capture this longitudinal experience. For patients, the number, timing, and impact of revision procedures represent meaningful outcomes that influence quality of life, satisfaction, and overall perception of reconstruction success [60]. Incorporating anticipated revision burden into preoperative counseling allows for more transparent decision-making and aligns reconstructive strategy with patient-specific risk tolerance.

Personalized Decision-Making After Breast-Conserving Therapy: Risk-Stratified Reconstructive Options

Reconstructive decision-making after breast-conserving therapy (BCT) is best conceptualized as a continuum of options rather than a discrete set of interchangeable techniques. Patient-specific risk factors, including tissue quality, radiation exposure, breast morphology, and tolerance for revision, should guide both the selection and sequencing of reconstructive interventions [14,15,49,61,62]. A risk-stratified framework allows surgeons to match reconstructive intensity to patient context, balancing aesthetic goals against the likelihood of complications and revision burden (Figure 1) [15].

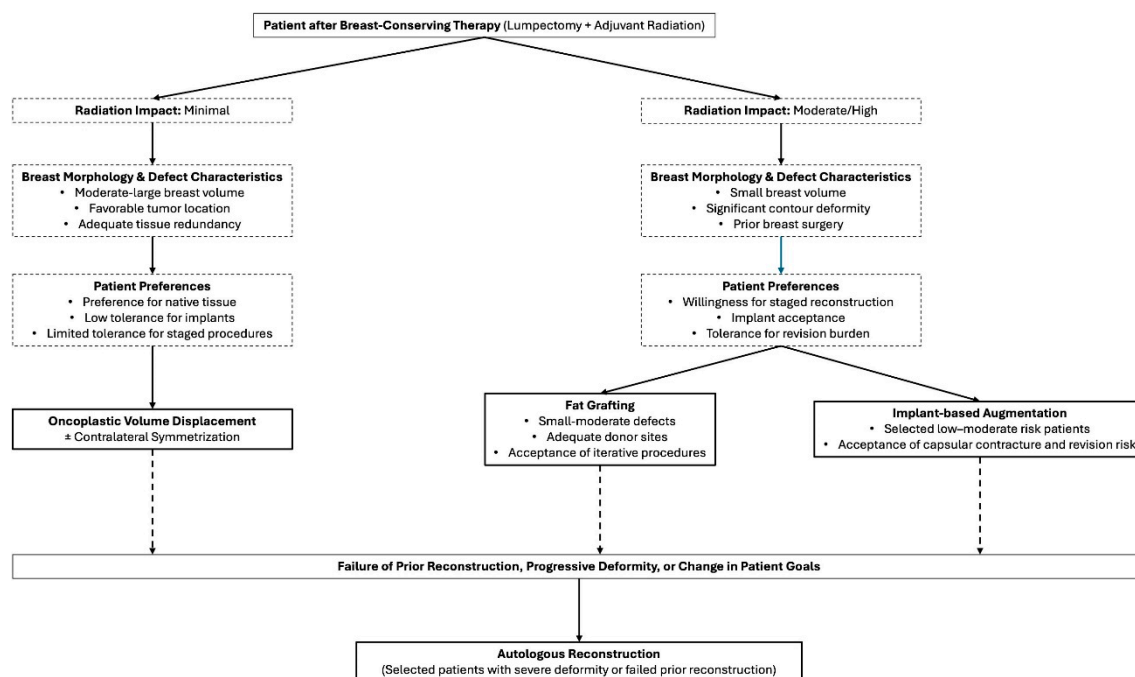


Figure 1. Framework for guiding personalized breast reconstruction after breast-conserving therapy.

Oncoplastic Volume Displacement Techniques

Oncoplastic volume displacement remains the preferred first-line reconstructive approach for many patients undergoing BCT, particularly those with moderate to large breasts and favorable tumor location [63,64]. By rearranging remaining breast tissue to fill the lumpectomy defect, these techniques preserve native tissue characteristics and avoid the introduction of foreign material or grafted fat into irradiated fields.

Patients with larger breast volume, sufficient tissue redundancy, and lower degrees of baseline asymmetry are generally best suited for volume displacement approaches [65,66]. Tumors located in the upper pole or lateral breast are often more amenable to these techniques, whereas lower pole and central defects may pose greater challenges [29,67]. Radiation exposure remains a critical modifier of outcomes; although oncoplastic rearrangement can be performed in irradiated tissue, fibrosis and volume contraction may compromise long-term symmetry [68].

Risk stratification is particularly important when considering contralateral symmetrization. While bilateral procedures can improve symmetry, they increase operative complexity and may not align with all patients' preferences or risk tolerance [69,70]. Personalized counseling should address the likelihood of delayed asymmetry due to radiation-related changes and the potential need for future revision even after initially successful oncoplastic reconstruction [23].

Implant-Based Augmentation After Lumpectomy

Implant-based augmentation following lumpectomy represents a distinct and under-discussed reconstructive pathway. This approach may be particularly appealing to patients with small breast volume, limited tissue redundancy, or pre-existing augmentation who desire restoration of volume rather than tissue rearrangement [17,71]. However, the introduction of implants into a partially irradiated breast fundamentally alters the risk profile and demands careful patient selection.

Radiation exposure is the dominant determinant of outcomes in this setting. Even when radiation is delivered in a partial or tangential field, capsular contracture, implant malposition, and aesthetic distortion are more common than in nonirradiated breasts [72,73]. The plane of implant placement further modulates risk. Subglandular placement may exacerbate visible contour irregularities in thin or fibrotic tissue, whereas subpectoral or prepectoral placement introduces

trade-offs related to animation deformity, implant coverage, and interaction with irradiated skin [74–78].

Patients with prior breast augmentation constitute a unique subgroup. In these individuals, implant exchange or augmentation after lumpectomy may appear straightforward but carries heightened risk of contracture and asymmetry when radiation is added to a previously unirradiated implant pocket [53,73,79]. Risk stratification should incorporate not only implant history but also patient expectations regarding long-term implant maintenance and tolerance for potential explantation or conversion to alternative reconstructive strategies.

Given these considerations, implant-based augmentation after BCT may be most appropriate for carefully selected patients with limited radiation exposure, favorable tissue quality, and a clear understanding of the likelihood of future revision. In this context, revision burden, rather than short term surgical complications, often represents the most meaningful outcome for patients.

Fat Grafting as Volume Replacement and Tissue Modulation

Autologous fat grafting occupies a central role in personalized reconstruction after BCT, offering both volume replacement and potential mitigation of radiation-induced tissue injury [58,80,81]. Its versatility allows it to be used as a primary reconstructive modality for small defects, an adjunct to oncoplastic rearrangement, or a salvage technique following implant-based reconstruction [80,82]. Patient selection is critical. Fat grafting is best suited for individuals with sufficient donor sites, realistic expectations regarding achievable volume, and willingness to undergo staged procedures [11]. In irradiated breasts, graft take may be unpredictable, and multiple sessions are often required [11,83]. While concerns regarding oncologic safety have diminished with accumulating evidence, ongoing surveillance considerations and patient anxiety may still influence acceptance of this approach [84,85].

From a personalization standpoint, fat grafting offers granular control over reconstructive intensity [86]. Small-volume grafting may address contour irregularities with minimal morbidity, while larger-volume reconstruction increases the likelihood of fat necrosis, calcifications, and need for revision [87]. Counseling should emphasize that fat grafting is frequently iterative and that aesthetic stability may evolve over time as radiation effects continue to unfold [58,83].

Autologous Reconstruction in Select Post-BCT Patients

Although less common, autologous tissue reconstruction may be indicated in select patients following BCT, particularly when prior reconstruction has failed or radiation-related deformity is severe [73,88]. These cases often represent salvage scenarios in which local tissue options have been exhausted or are no longer viable [88]. Risk stratification is essential when considering autologous reconstruction in this population. Patients must be evaluated for donor site suitability, overall medical fitness, and willingness to undergo more extensive surgery [73]. While autologous tissue may offer improved durability and aesthetic outcomes in heavily irradiated fields, the morbidity of flap-based reconstruction must be weighed against patient goals and expectations [42,61].

Integrating Risk Stratification into Technique Selection

Rather than viewing reconstructive options as competing alternatives, a personalized approach frames them as complementary tools that can be sequenced or combined based on evolving risk profiles. Patients with low-risk features may achieve durable results with oncoplastic rearrangement alone, whereas higher-risk individuals may require staged fat grafting, implant augmentation with careful counseling, or eventual conversion to autologous reconstruction [73,89]. This risk-stratified paradigm emphasizes adaptability over rigidity. As tissue characteristics and patient priorities change over time, reconstructive strategy should be revisited, reinforcing the importance of longitudinal planning and shared decision-making in reconstruction after BCT.

Personalized Decision-Making After Breast-Conserving Therapy: Timing of Reconstruction

The timing of reconstruction following breast-conserving therapy (BCT) is a critical and highly individualized decision that significantly influences both aesthetic outcomes and complication risk (Table 2) [45,73,90]. Unlike mastectomy reconstruction, where immediate reconstruction is often encouraged to preserve the skin envelope and streamline care, reconstruction after BCT must account for the evolving biological effects of radiation, oncologic treatment sequencing, and patient readiness for additional surgery [45].

Table 2. Personalized timing strategies for reconstruction after breast-conserving therapy.

| Reconstruction Timing | Advantages | Limitations | Best Candidates |
|------------------------------|---------------------------|------------------------------|--------------------------------|
| <i>Immediate</i> | Early contour restoration | Radiation effects may evolve | Low-risk, favorable anatomy |
| <i>Delayed</i> | Stable tissue assessment | Fibrosis, staged care | Higher-risk, irradiated tissue |
| <i>Staged</i> | Adaptable, incremental | Multiple procedures | Patients tolerant of revisions |

Immediate Versus Delayed Reconstruction

Immediate reconstruction at the time of lumpectomy or shortly thereafter may be appropriate for select patients with favorable risk profiles, limited anticipated radiation effects, and clear reconstructive goals [73,90]. Oncoplastic volume displacement techniques are most employed in this setting, as they allow defect correction using native tissue before radiation-induced fibrosis becomes established [14,91,92]. For appropriately selected patients, immediate reconstruction may reduce the need for later interventions and provide early restoration of breast contour [92,93]. However, early intervention carries the risk of underestimating the extent of radiation-related changes that may emerge over time. Volume loss, skin contraction, and asymmetry may progress months to years after treatment, potentially diminishing the durability of immediate reconstructive results [19]. For patients with higher-risk features, such as extensive radiation fields, smaller breast volume, or medical comorbidities, delayed reconstruction may offer a more predictable foundation for long-term outcomes [45,94].

Reconstruction in the Post-Radiation Setting

Delayed reconstruction allows surgeons to assess the stable effects of radiation before intervening, facilitating more accurate planning and patient counseling [45,73]. In this context, reconstructive techniques such as fat grafting or implant-based augmentation can be tailored to the established tissue environment. However, delayed intervention must contend with fibrosis, reduced tissue compliance, and compromised vascularity, all of which increase the likelihood of staged procedures and revision surgery [73]. Personalization is particularly important when considering delayed implant-based reconstruction. While some patients may tolerate implant placement in a radiated breast with acceptable outcomes, others may experience progressive capsular contracture or aesthetic distortion over time [45,95,96]. Incorporating patient-specific risk factors into timing decisions helps align reconstructive strategy with long-term expectations and tolerance for revision [73,89].

Staged and Sequential Reconstruction

Many reconstructive pathways after BCT are inherently staged, reflecting both biologic realities and patient preferences. Fat grafting is often performed in multiple sessions to gradually restore volume and improve tissue quality [58,83]. Staging allows for incremental assessment of graft take,

contour improvement, and patient satisfaction while minimizing morbidity [97]. Sequential approaches may also involve escalation of reconstructive intensity over time. Patients initially managed with conservative interventions may later pursue more extensive reconstruction as tissue characteristics stabilize or aesthetic priorities evolve [27,73]. This adaptability underscores the importance of framing reconstruction after BCT as a longitudinal process rather than a single operative event.

Ultimately, the optimal timing of reconstruction after BCT must integrate oncologic considerations, tissue biology, and patient-centered goals [45,73,98]. Transparent discussion of the trade-offs associated with early versus delayed intervention, including the likelihood of revision, durability of results, and impact on quality of life, is essential to personalized decision-making [98]. By tailoring timing to individual risk profiles and expectations, surgeons can better align reconstructive planning with outcomes that matter most to patients [98].

Risk Prediction, Patient Counseling, and Shared Decision-Making in Personalized Reconstruction

Personalized reconstruction after breast-conserving therapy (BCT) depends not only on technical execution but on accurate risk prediction and effective patient counseling. Given the heterogeneity of tissue characteristics, treatment history, and patient priorities in this population, shared decision-making must be grounded in transparent discussion of both short-term risks and long-term reconstructive trajectories [73,99,100].

Limitations of Existing Risk Prediction Tools

Existing risk prediction models in breast reconstruction have largely been developed in the context of mastectomy-based reconstruction and do not adequately account for the unique variables encountered after BCT [101–103]. Factors such as nonuniform radiation fields, partial volume loss, and evolving tissue fibrosis are difficult to capture in traditional calculators that focus on binary outcomes such as infection or implant loss [102,104]. As a result, these tools may underestimate the likelihood of delayed complications or revision surgery in the post-BCT population.

Moreover, many commonly reported outcomes fail to reflect patient priorities. Complication rates reported at 30 or 90 days do not capture longitudinal changes in breast contour, progressive asymmetry, or the cumulative burden of staged procedures [102,105,106]. This mismatch between measured outcomes and lived patient experience limits the utility of existing models for counseling patients considering reconstruction after BCT.

Incorporating Revision Burden into Counseling

For patients undergoing reconstruction after BCT, the probability and frequency of revision procedures represent clinically meaningful outcomes that should be incorporated into preoperative counseling [27]. Techniques such as fat grafting and implant-based augmentation often require multiple interventions to achieve durable results, particularly in irradiated tissue [11,45,58,83]. Framing reconstruction as a process rather than a single operation helps set realistic expectations and allows patients to weigh aesthetic benefits against the time, recovery, and emotional investment associated with staged care.

Personalized counseling should explicitly address how individual risk factors, such as radiation exposure, breast size, and comorbidities, influence the likelihood of revision. By normalizing the need for secondary procedures in appropriate contexts, surgeons can reduce dissatisfaction and enhance alignment between patient expectations and surgical outcomes [107].

Shared Decision-Making as a Core Component of Personalization

Shared decision-making is central to personalized reconstruction after BCT. Patients bring diverse values and priorities to reconstructive planning, including tolerance for asymmetry,

willingness to undergo multiple procedures, and preferences regarding implants or autologous tissue [108]. These considerations often carry equal weight to physiologic risk factors and must be integrated into reconstructive recommendations [108]. Effective shared decision-making requires clear communication of uncertainty, particularly in scenarios where long-term outcomes are difficult to predict [109,110]. Visual aids, decision trees, and examples of anticipated reconstructive trajectories may help patients contextualize risk and make informed choices that align with their goals [99,111,112].

There is a clear need for reconstruction-specific frameworks tailored to patients treated with BCT. Future efforts should focus on developing predictive models that incorporate radiation characteristics, breast morphology, and patient-reported outcomes alongside traditional complication metrics. Institutional data and multicenter registries may play a critical role in refining these tools and validating their applicability to diverse patient populations [113,114]. By integrating risk prediction with patient-centered counseling and shared decision-making, personalized reconstruction after BCT can move beyond technique-driven algorithms toward care pathways that prioritize durability, satisfaction, and alignment with individual patient goals.

Future Directions

As the population of patients treated with breast-conserving therapy (BCT) continues to grow, there is an increasing need for reconstructive paradigms that move beyond technique-driven decision-making toward truly personalized care. Several emerging areas offer opportunities to improve risk prediction, patient selection, and long-term outcomes in this population.

First, the development of BCT-specific predictive models represents a critical unmet need. Existing reconstruction risk calculators do not adequately incorporate the heterogeneity of radiation fields, partial-volume tissue loss, or longitudinal changes in breast morphology that characterize post-BCT patients [113–117]. Future models should integrate treatment-specific variables, such as radiation dose distribution and timing, with patient-level factors and reconstructive technique to more accurately predict complications, revision burden, and patient-reported outcomes.

Second, advances in imaging and intraoperative assessment may enhance personalization of reconstructive planning. Preoperative imaging techniques that characterize tissue quality and vascularity, as well as intraoperative tools that assess perfusion, could help refine patient selection and guide technique choice in compromised tissue environments [118–121]. These technologies may be particularly valuable in identifying patients who are unlikely to tolerate implant-based reconstruction or who may benefit from staged fat grafting or autologous approaches.

Third, incorporation of patient-reported outcomes into both clinical practice and research is essential to advancing personalized reconstruction after BCT. Instruments that capture satisfaction, body image, and quality of life over time can provide insights into how reconstructive strategies align with patient priorities and may help identify subgroups that benefit most from specific approaches [122,123]. Embedding these measures into registries and longitudinal studies will be critical for refining shared decision-making frameworks.

Finally, future research should emphasize longitudinal follow-up and durability of outcomes [8,96,122]. Reconstruction after BCT is often an evolving process, and short-term metrics fail to capture the full patient experience [8,19]. Studies that assess outcomes over years rather than months will be essential to understanding how personalized strategies perform over time and to informing evidence-based counseling.

Conclusions

Reconstruction after breast-conserving therapy occupies a distinct and under-recognized space within breast reconstruction, characterized by heterogeneous tissue environments, evolving radiation effects, and highly individualized patient goals. A personalized, risk-stratified approach offers an effective framework for reconstructive planning after BCT. By integrating patient-specific

risk factors, treatment history, and psychosocial preferences, surgeons can tailor technique selection and timing to optimize durability, minimize revision burden, and align outcomes with patient expectations. Importantly, meaningful outcomes in this setting extend beyond short-term complications to include long-term aesthetic stability and patient-reported satisfaction. By embracing personalization as a guiding principle, reconstructive strategies after breast-conserving therapy can best align with the diverse needs and priorities of patients navigating survivorship.

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