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PRESERVING AND RESTORING SENSATION AFTER NIPPLE SPARING MASTECTOMY THROUGH NERVE PRESERVATION AND NIPPLE AREOLAR COMPLEX NEUROTIZATION

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ABSTRACT

Preserving the nipple–areolar complex during mastectomy does not ensure that its sensory function is retained. This narrative review evaluates nerve preservation and nipple–areolar complex neurotization, distinguishing objective sensory recovery from patient-reported benefit and surgical safety. A focused PubMed search was performed, supplemented by targeted searches for anatomical, methodological, and reconstructive publications and review of available full texts. The synthesis included clinical series, comparative studies, a small randomized conference report, anatomical investigations, and relevant consensus publications, without quantitative pooling. Early implant-based reconstruction studies reported encouraging recovery of tactile sensibility, but several lacked concurrent controls. Comparative observational evidence suggests potential psychosocial and sexual well-being benefits, although reconstruction type and treatment selection complicate causal interpretation. A six-patient randomized split-chest report did not demonstrate significant sensory differences, emphasizing the preliminary nature of the evidence. Larger matched database research provides reassurance regarding recorded postoperative complications but does not establish sensory efficacy or oncologic equivalence. Assessment methods vary substantially, encompassing pressure thresholds, two-point discrimination, and patient-reported measures. Nerve preservation and neurotization are promising components of functional breast reconstruction, provided that they do not alter the required oncologic resection. Standardized baseline and longitudinal assessment, adequately powered comparative studies, and transparent counseling are needed before the magnitude, durability, and generalizability of benefit can be established.

KEYWORDS

Nipple-Sparing Mastectomy, Neurotization, Intercostal Nerves, Breast Sensation, Breast Reconstruction, Patient-Reported Outcomes

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Introduction

Nipple-sparing mastectomy (NSM) preserves the external nipple–areolar complex (NAC) while removing breast glandular tissue. Its reconstructive value must be weighed against a functional limitation: the retained nipple may remain substantially less sensitive after surgery. In a prospective study, Dossett et al. [1] documented reduced postoperative sensation after both nipple-sparing and skin-sparing procedures. These findings support measuring sensation as an outcome of reconstruction rather than assuming that it follows from anatomical preservation. Clinical assessment must therefore consider what patients perceive after treatment, alongside NAC survival and appearance.

The distinction between appearance and function is particularly relevant to treatment decisions with implications for long-term survivorship. The BREAST-Q Sensation Module was developed to assess symptoms, sensation, and the impact of sensory loss from the patient perspective [2]. Although patients differ in the importance they assign to nipple sensation, sensory experience warrants direct measurement. A reconstruction considered successful on the basis of shape, symmetry, or absence of complications may still leave an important patient priority unaddressed.

Two related approaches seek to address this functional loss. Nerve preservation seeks to retain a sensory pathway during the oncologic operation when anatomically and oncologically feasible. Neurotization reconstructs a pathway by connecting a proximal sensory nerve to a distal nerve or target tissue, often using an interposition graft. Early experience in implant-based reconstruction combined these maneuvers without testing their effects independently [3]. Sensory recovery after a combined procedure therefore cannot be attributed entirely to grafting on the basis of these reports alone. Preserved nerves, spontaneous recovery, patient selection, and the reconstructive technique may all influence the observed result.

Anatomical evidence provides a rationale for intervention, although it cannot establish clinical effectiveness. Anatomical investigations identify important intercostal contributions to breast and NAC

innervation, with variation in the course of the relevant branches [4, 5]. A visible nerve may be useful during surgery even when it cannot safely be preserved along its entire course. The operative challenge is to apply this knowledge while completing the indicated tissue removal. A functional reconstruction must remain subordinate to the oncologic procedure, including decisions about the NAC itself.

Research has progressed from feasibility reports to prospective sensory assessment, comparative studies of patient-reported outcomes, and larger analyses of postoperative morbidity. Nevertheless, encouraging series coexist with a very small randomized report that did not demonstrate significant differences between neurotized and non-neurotized breasts [6]. This evidence warrants an appraisal of what each study design can establish, whether the study population represents the intended patient, and which sensory domain was measured, without dismissing the intervention or treating its benefit as settled.

An interdisciplinary assessment of neurotization as a health technology must extend beyond operative capability. A measurable sensory change has clinical meaning when it addresses a function valued by the patient, with acceptable burdens, uncertainty, and requirements for access. Cost, communication, and outcome assessment should therefore accompany technical innovation. These considerations follow from interpreting the evidence; they do not show that neurotization has already improved population health or reduced inequity. The review addresses this distinction by integrating surgical findings with patient-centered interpretation while avoiding unsupported economic or social claims.

This review critically synthesizes the available evidence on nerve preservation and NAC neurotization after NSM, focusing on anatomical rationale, technical approaches, objective sensory outcomes, patient-reported outcomes, complications, and oncologic boundaries. It also proposes a practical framework for assessment and future research. Evidence from autologous reconstruction is considered where it clarifies mechanisms or study design, with a clear distinction between flap reinnervation and restoration of sensation in the retained NAC over an implant.

Methodology

This focused narrative review addresses nerve preservation and nipple–areolar complex neurotization after nipple-sparing mastectomy. The PubMed search combined nipple-sparing mastectomy terminology with terms for neurotization, reinnervation, nerve preservation, and sensation. The query returned 62 records, with no publication-date restriction. Targeted supplementary searches were used to identify anatomical, reconstructive, and methodological studies and consensus documents.

Human studies of sensation after NSM were prioritized, particularly those involving implant-based reconstruction. Studies of autologous flaps provided contextual evidence and were identified separately. Bibliographic data were checked against PubMed records and available full texts. Where the full text was unavailable, analysis was restricted to the abstract. The 2026 randomized report was assessed as a conference abstract.

Study design, patient and breast denominators, techniques, sensory assessment, follow-up, patient-reported outcomes, and complications were compared. Findings were synthesized qualitatively, without meta-analysis or a formal risk-of-bias assessment.

Results

Anatomical basis of sensory preservation

The breast receives cutaneous input through anterior and lateral intercostal branches. Jaspars et al. [4], in a cadaveric investigation, identified consistent fourth-intercostal contributions to the NAC and additional third- and fifth-intercostal input. These findings support consideration of several potential pathways, as the nerve arrangement may differ between patients. They also explain why a retained nipple may lose sensation when its deeper connections are interrupted. Anatomical preservation of the NAC must therefore be distinguished from continuity of its afferent pathway.

More recent mapping provides operative landmarks. Knackstedt et al. [5] localized lateral sensory nerves in bilateral dissections of ten female cadavers, while Gardetto et al. [7] examined the emergence of the fourth intercostal lateral cutaneous branch in a separate donor sample. These anatomical landmarks can guide intraoperative identification and surgical training. However, cadaveric localization cannot predict individual postoperative recovery, confirm intraoperative nerve viability, or determine whether preserving a particular

branch is compatible with complete cancer resection. Anatomical evidence thus helps establish how an intervention might be performed, without demonstrating its outcomes.

Interpretation of clinical reports requires a distinction between three structures: the proximal sensory source, any preserved distal branch, and the final sensory target. Dissection of an intercostal stump does not necessarily imply uninterrupted nerve preservation to the nipple. Similarly, a nerve connected to flap tissue is not necessarily a nerve connected to the retained NAC. These distinctions are essential when comparing techniques grouped under the broad term breast neurotization. Without identifying the target, a positive sensory result can be transferred incorrectly from one reconstructive setting to another.

Nerve preservation and reconstruction as complementary approaches

In the initial implant-based report, Peled and Peled [3] combined careful nerve preservation with allograft-assisted NAC reconstruction. Among 23 breasts in 12 women with at least three months of follow-up, two-point discrimination was preserved in 20 breasts. Although the series established feasibility and reported favorable early sensory findings, it had no concurrent control group. The findings demonstrate that a sensory-oriented operative strategy can be performed with immediate implant reconstruction, but do not isolate the contribution of nerve preservation from that of the graft.

Technical publications describe how reinnervation can be adapted to different incisions and reconstructive pathways. Gfrerer et al. [8] discuss targeted NAC reinnervation in both tissue-expander and direct-to-implant reconstruction. Coopey et al. [9] describe operative strategies for identifying and preserving relevant nerves. These reports inform technique development; they do not provide randomized comparisons of incision choice, preservation alone, or reconstruction alone. Describing a technical solution requires different evidence from demonstrating its superiority over an alternative.

Future reports could classify each breast according to whether a sensory pathway was preserved continuously, reconstructed after transection, or both. The graft material, proximal nerve, distal target, reconstruction stage, and final graft route should then be recorded. This proposed classification would distinguish interventions intended to prevent denervation from those intended to repair an unavoidable interruption. It could also clarify cases in which the planned maneuver changes during surgery because the nerve cannot safely be retained.

A further reporting proposal is to distinguish planned, attempted, completed, and abandoned sensory procedures. Reporting only completed repairs can hide the practical limitations encountered during resection. A repair abandoned because of an unsuitable nerve, an oncologic constraint, or an unworkable route remains relevant to feasibility, even though no graft was placed. Recording the reason would help patients and clinicians assess how often a preoperative plan can be carried out. It would also distinguish failure of surgical access from failure of sensory recovery after a completed repair; these outcomes require different explanations and may call for different improvements.

Implant-based neurotization and objective recovery

Djohan et al. [10] reported early recovery after implant-based NAC neurotization, with objective follow-up available for eight patients and 15 breasts from a larger treated group. Pressure-specified sensory testing showed improvement over time. These findings support the possibility of postoperative sensory recovery, although the small tested sample and incomplete repeated observations limit interpretation. The numbers treated and tested must be distinguished: the denominator for an operative series does not necessarily apply to every sensory result.

Peled et al. [11] prospectively assessed 47 women with 79 breasts after NSM and immediate prepectoral direct-to-implant reconstruction. Mean follow-up was 9.2 months. The study reported favorable static and moving pressure-threshold categories at six months, with the underlying outcomes also presented by tested location and time point. These categories should not be translated into a universal probability of normal nipple sensation. As the full report indicates, sensory testing was available for a subset of the wider treated population, which must be considered when assessing representativeness.

The same report included no patients exposed to radiotherapy and lacked a non-neurotized control group [11]. Its findings therefore cannot establish the effect in irradiated breasts or demonstrate the magnitude of improvement relative to contemporary NSM without nerve reconstruction. These limitations do not invalidate the measured recovery, but leave the counterfactual uncertain: the study describes outcomes after the combined procedure more clearly than it establishes what would have happened to the same patients without it.

Guido et al. [12] subsequently reported the timing of sensory return in 47 patients with 94 breasts. At 12 months, 74% of patients reached the study's excellent pressure-testing category, and patients also reported increasing sensation over time. The report suggested better recovery following bilateral risk-reducing procedures than following cancer treatment. This observation may generate hypotheses, but it does not identify the treatment or patient factor responsible for the difference. Statistical independence from other reports from the same clinical program should not be assumed without checking patient inclusion periods.

Zhang et al. [13] studied operative nerve length planning in 58 patients undergoing implant-based reconstruction and reported improvement in sensory testing during follow-up. The study highlights the practical variability of graft routing and reconstructive geometry. The planning approach must be interpreted in the context of the cohort and technique studied. It does not establish a universally optimal graft length; a geometrical estimate alone should not be taken as proof of superior sensory recovery from a particular nerve repair.

What recovery without neurotization tells us

Baseline studies provide essential context for comparison, even when they cannot serve as matched controls. Dossett et al. [1] prospectively enrolled 53 patients: 38 choosing NSM and 15 choosing skin-sparing mastectomy. One-year sensory data were available for 33 NSM patients and 13 skin-sparing mastectomy patients. Substantial sensory loss was documented; measurable sensation in both NACs remained in only a subset of patients. A discrepancy between the percentage reported in the abstract and in the full article results limits the precision of this estimate. Patients selected their procedure, and the study did not test the incremental effect of modern neurotization. For this review, its value lies in showing why nipple preservation should not be equated with preservation of sensation.

Soares Domingues Polita et al. [14] followed 42 patients with 66 breasts after NSM and implant or expander reconstruction. Sensation declined early and showed partial return over the subsequent year. This pattern shows why postoperative improvement within a neurotized cohort alone cannot establish a treatment effect. Comparators must be assessed over the same interval and with the same instrument, since sensory change can occur without the intervention under investigation. Historical studies using different maps or scales cannot reliably supply that missing comparison.

These studies also underscore the distinction between recovery and restoration. A patient's postoperative threshold may improve while remaining worse than baseline. Interpretation depends on the target outcome: any perception, a protective threshold, the preoperative level, or sensation that patients value in daily life. Reporting only that sensation returned obscures these distinctions. Results should therefore report the absolute postoperative measure and its relationship to baseline, specifying the anatomical location and how the chosen scale should be interpreted.

Neurotization during staged reconstruction

Telich-Tarriba et al. [15] reported a prospective series of 13 patients with 18 breasts in which nipple reinnervation was performed during expander-to-implant exchange. Monofilament thresholds improved from more than 300 g before that intervention to 10 g at six months and 2 g at 12 months. The study had no contemporary non-neurotized comparison group. The findings extend the clinical context beyond immediate direct-to-implant reconstruction, without establishing that second-stage intervention is equivalent or superior to immediate neurotization.

Baseline timing is particularly important here: testing before second-stage neurotization takes place after mastectomy, whereas testing before immediate reconstruction precedes it. Changes measured from these baselines therefore answer different questions. A staged series may demonstrate improvement in an already denervated nipple without showing recovery to its original premastectomy state. Future comparisons should therefore retain both time anchors and specify whether the desired outcome concerns recovery after mastectomy, improvement after the nerve intervention, or restoration relative to the original sensory baseline.

Autologous reconstruction and transferability

Tevlin et al. [16] reported targeted NAC reinnervation during immediate autologous reconstruction in a retrospective analysis of 14 breasts. Unlike studies targeting the skin of a transferred flap, this proof-of-concept study addressed a retained nipple over autologous tissue. Its small retrospective comparison, however, cannot establish comparative effectiveness across reconstructive types. Preserved skin, transferred skin, and NAC sensation should remain separate outcome domains whenever they are assessed.

Bubberman et al. [17] provided interim results from a double-blind randomized study of DIEP flap nerve coaptation. Forty-one patients contributed 29 innervated and 38 non-innervated breasts. At 24 months, mean flap-skin monofilament values were lower in the innervated group, and thermal testing also favored coaptation. These randomized findings are relevant to sensory flap reconstruction. Because the tissue target and operative context differ, they do not demonstrate that NAC allografting over an implant produces the same benefit.

Chang et al. [18] investigated an intercostal autograft approach in a retrospective case-control study involving 56 neurotized patients across several reconstructive settings. The neurotized group had better monofilament thresholds than the non-neurotized comparison group, and recovery varied with follow-up duration. The study also reported two pleural injuries during dissection. These findings indicate the potential of an alternative graft strategy while highlighting the need to document technique-specific harms. Given the mixed population, not every pooled result can be attributed specifically to immediate implant-based NSM.

The applicability of related evidence depends on the nerve pathway and sensory target, rather than the label neurotization alone. Randomized flap research can inform measurement and study design. Mixed reconstruction studies can identify feasibility and possible mechanisms. Neither can replace a controlled study of the specific intervention and population under consideration. Maintaining this distinction avoids overstating the directly applicable evidence while acknowledging the contribution of related reconstructive research.

Patient-reported sensation and well-being

Shyu et al. [19] compared 67 neurotized and 65 non-neurotized patients in a prospective cohort. The neurotized group had higher psychosocial and sexual well-being scores, with reported means of 71.6 versus 62.8 and 56.9 versus 47.3, respectively. These findings show an association between the intervention and patient-reported outcomes within that cohort, without establishing causation or a universally applicable clinically important difference. Interpretation must account for reconstruction type, treatment exposure, and assessment timing.

The distribution of reconstruction types is particularly important: the neurotized group included 60 autologous reconstructions but only seven implant reconstructions, whereas the comparison group included 30 autologous and 35 implant reconstructions [19]. The favorable whole-cohort result therefore provides limited implant-specific evidence. Although subgroup findings may be informative, a seven-patient intervention subgroup cannot resolve all confounding or provide precise estimates for the wider implant-based population.

The BREAST-Q Sensation Module provides separate scales for sensory experience, related symptoms, and the quality-of-life impact of sensory loss [2]. These separate scales help prevent touch thresholds from being used as proxies for sexual well-being or overall satisfaction. A patient may register a laboratory stimulus without experiencing the sensation as useful, comfortable, or personally meaningful. Conversely, a modest objective change may matter to a patient in everyday life. Both perspectives warrant measurement, as changes in one may not parallel changes in the other.

Controlled evidence and discordant findings

Hemal et al. [6] reported a randomized split-chest study in which one breast was neurotized and the contralateral breast was not. Six patients were included, and 12-month follow-up was available for four. No significant sensory differences between sides were reported. As a conference abstract describing a very small sample, the report cannot establish equivalence or exclude a clinically meaningful benefit. It nevertheless cautions against interpreting every favorable early series as evidence of a large, consistent causal effect.

The split-chest design allows comparison between sides that share some patient-level factors. Nevertheless, observations from two breasts are correlated, and whole-person outcomes such as sexual well-being cannot always be assigned cleanly to one randomized side. The design also does not eliminate all breast-level differences. Future trials should state how paired observations, repeated testing, missing visits, and subjective outcomes will be analyzed. Within-patient comparison is most informative when these methodological considerations are incorporated into study design rather than addressed after data collection.

The contrast between improvement in uncontrolled studies and the absence of a significant randomized finding primarily raises questions about evidence quality, rather than demonstrating a biological contradiction. Several explanations remain possible: limited power, variation in repair, spontaneous recovery, selected populations, or differences in measurement. The available studies do not establish the relative contribution of these explanations. These possibilities should remain open pending a larger, complete comparative report; neither type of study should be treated as definitive.

Complications and resource use

Boyd et al. [20] compared 26 neurotized breasts in 15 patients with 52 matched control breasts in 30 patients. They did not identify significant differences in major or minor complications and reported a mean added cost of US\$7,839 per breast. This single-institution estimate cannot be assumed to apply elsewhere and does not constitute a cost-effectiveness result. It shows that implementation involves measurable resource use alongside the intended sensory benefits. Clinical value cannot be inferred from a cost figure without an appropriate comparator, outcome horizon, and perspective.

Chaudhry et al. [21] examined a larger administrative dataset. Following matching, 759 patients remained in each group, and no significant difference in major postoperative complications was found at the reported intervals. These findings provide reassurance about recorded postoperative morbidity beyond that available from small operative series. However, coded clinical data do not establish detailed sensory performance, exact nerve technique, or long-term cancer control. The larger sample strengthens assessment of the endpoints captured, without providing evidence on outcomes that the dataset did not measure.

Technique-specific risks should also be considered separately from general reconstructive complications. The pleural injuries reported by Chang et al. [18] illustrate why an autograft dissection strategy may have a different harm profile from an allograft strategy. Infection and implant loss should be distinguished from donor-nerve morbidity and injuries incurred while obtaining additional nerve length. A complete assessment should identify the operative step that could plausibly account for each event and specify the denominator used.

Evidence overview

Table 1 summarizes selected directly relevant clinical reports. The reports are presented without pooling. Patients and breasts are presented separately where available, and study-defined sensory categories are not harmonized retrospectively. Related series may overlap; their denominators should not be added to estimate a total independent population. The table emphasizes what the evidence supports and where it limits interpretation, without ranking techniques by unadjusted success percentages.

Table 1. Selected clinical evidence and interpretive limitations

Study and population	Assessment	Main observation	Limitations
Peled & Peled [3] Pilot series 16 women; 31 breasts; sensory follow-up ≥ 3 months: 12 women, 23 breasts	Two-point discrimination; early postoperative testing	Preserved discrimination in 20/23 evaluated breasts	No concurrent controls; short follow-up; combined preservation and grafting
Djohan et al. [10] Clinical series 13 treated patients; 8 patients, 15 breasts assessed	Pressure-specified sensory device; repeated testing in a subset	Sensory thresholds improved with time	Small measured sample; incomplete repeated observations
Peled et al. [11] Prospective sensory cohort 47 women; 79 breasts assessed	Static and moving pressure thresholds; mean follow-up 9.2 months	Favorable sensory categories at 6 months	No controls or irradiated patients; tested subset of treated population

Study and population	Assessment	Main observation	Limitations
Chang et al. [18] Retrospective case-control study 56 neurotized patients	Monofilaments; mixed settings and follow-up intervals	Better thresholds than non-neurotized comparison; 2 pleural injuries reported	Mixed procedures; selection and technique-specific risks
Shyu et al. [19] Prospective comparative cohort 67 neurotized; 65 controls	Monofilaments, BREAST-Q, additional questionnaire; ≥ 1 -year follow-up	Higher psychosocial and sexual well-being scores in neurotized group	Reconstruction imbalance; only 7 implant cases in intervention group
Boyd et al. [20] Matched retrospective comparison 15 patients/26 breasts vs. 30/52	30-day complications and local added cost	No significant complication difference; added cost reported	Small sample; unequal follow-up; no cost-effectiveness analysis
Chaudhry et al. [21] Matched administrative cohort 759 patients per group	Recorded complications at 6 months, 1 year and 3 years	No significant difference in major complications	Coding limitations; no direct sensory or oncologic-efficacy endpoint
Hemal et al. [6] Randomized split-chest abstract 6 patients; 4 at 12 months	Monofilaments; BREAST-Q; blinded sensory assessment	No significant between-side sensory difference	Very small trial; abstract only; does not establish equivalence
Telich-Tarriba et al. [15] Prospective staged series 13 patients; 18 breasts	BMRC and monofilaments; 6 and 12 months after implant exchange	Improved sensory thresholds after second-stage reinnervation	No contemporary controls; baseline followed mastectomy

Note. BMRC = British Medical Research Council sensory scale. Counts are not pooled; cohorts may overlap. Findings are study-specific and do not demonstrate oncologic equivalence.

Discussion

Interpreting benefit at the correct level

The available literature supports feasibility and the possibility of meaningful sensory recovery, although the incremental causal benefit remains incompletely defined. The systematic synthesis by Sorenson et al. [22] similarly emphasizes heterogeneous techniques and limited study designs in implant-based NAC neurotization. Feasibility, postoperative recovery, comparative superiority, and durable patient benefit should therefore be considered as successive questions. Evidence addressing one question does not necessarily resolve the next. This framework can guide both the wording of clinical reports and the claims made during patient counseling.

An intervention can be technically successful if a graft is placed and the repair remains intact, yet clinically unsuccessful if the patient perceives little useful sensation. A sensory test can improve without returning to baseline. A patient-reported measure can improve for reasons partly unrelated to the nerve repair. Reports should therefore specify which level of success is being claimed. A convincing study would relate technical execution to a prespecified sensory endpoint and, in turn, to an outcome valued by patients, avoiding selection of whichever measure appears most favorable after surgery.

The earlier review by Harish et al. [23] highlighted the wide variation in how nipple sensitivity is assessed. This variation affects clinical interpretation as well as reporting. Light touch, moving pressure, two-point discrimination, protective sensation, and erotic sensation describe different capacities. Their thresholds, units, and scoring systems are not interchangeable. A report that many patients achieved good sensation can be interpreted clinically only if it specifies the tested modality, body region, time point, and definition of good.

The current evidence also requires a distinction between potential benefit and prediction for an individual patient. Encouraging group results justify further evaluation and discussion of the option. They do not justify promising a particular patient that sensation will be normal, that a nipple will respond as before, or that pain will be prevented. Individual prediction requires sufficiently representative data and validated prognostic assessment. This narrative synthesis identifies no validated prediction model that could provide such assurances in routine practice.

Measurement and a proposed assessment framework

The proposed framework for clinical assessment and research begins with baseline testing before mastectomy. The breast skin, areola, and nipple should be mapped separately; each tested modality and unit should be recorded. The same locations and procedures should be used at follow-up so that observed changes reflect the intended measurement rather than a change in technique. This recommendation responds to the heterogeneity of the literature; it is not an established IJITSS or surgical-society protocol. Its purpose is to make future observations comparable and auditable.

Objective testing should be complemented by a validated patient-reported instrument, such as the BREAST-Q Sensation Module, used according to its scoring instructions [2]. Symptoms and the functional meaning of sensation should remain distinct domains. A study should state whether it seeks improvement in tactile detection, protective function, comfort, quality of life, or several prespecified outcomes. Prespecifying these aims would reduce the risk of substituting an unrelated positive secondary finding for a negative primary finding, leaving the original clinical question unanswered.

Longitudinal reporting should include the number assessed at each visit and the reasons for missing observations where known. A favorable mean among returning patients may not represent the outcome of all treated patients. At the same time, missing follow-up does not prove a poor result. Transparent reporting and an appropriate sensitivity analysis are therefore needed, without assuming either a favorable or an unfavorable result. This is particularly important for sensory procedures, as meaningful change may continue during a period in which follow-up attendance becomes incomplete.

Analysis must also account for the structure of repeated measurements. Bilateral breasts, multiple sensory sites, and several follow-up visits create related observations within a patient. Treating each observation as independent would inflate the apparent sample relative to the actual number of independent participants. Future comparative studies should prespecify the patient or breast as the unit of allocation and analysis, explain the handling of correlated measurements, and provide estimates of between-group differences with confidence intervals rather than relying only on whether a *p* value crosses a threshold.

Oncologic boundaries

The Oncoplastic Breast Consortium consensus addresses NSM selection and operative decision-making, including the relevance of the NAC and resection margins [24]. The consensus provides an oncologic context for sensory reconstruction without specifically endorsing every nerve-preserving or grafting technique. In sensory-oriented surgery, the operative boundary must be explicit: preserving a nerve is acceptable only when the required oncologic resection is completed. If the nerve pathway traverses tissue that must be removed, functional aims cannot justify leaving that tissue behind.

A study of postoperative complications does not establish oncologic equivalence. Infection, wound disruption, explantation, and capsular contracture concern reconstructive morbidity. Cancer recurrence, involved margins, retained glandular tissue, and treatment delay concern different outcomes. The large matched analysis by Chaudhry et al. [21] is reassuring for its recorded complication endpoints but should not be interpreted as evidence of cancer safety. Answering that question directly would require a registry linking the operative nerve strategy with pathological findings and longer-term oncologic follow-up.

The distinction also applies to therapeutic and risk-reducing mastectomy. Differences in clinical constraints and subsequent treatment exposure mean that favorable results in one setting cannot be assumed in the other. The subgroup pattern reported by Guido et al. [12] suggests that this distinction deserves investigation. It does not establish that the indication itself is the causal determinant of recovery. More specific expectations for counseling require detailed information on treatment and baseline characteristics.

Radiotherapy and reconstructive context

Radiotherapy requires multidisciplinary planning because it interacts with the timing and type of reconstruction. The Oncoplastic Breast Consortium recommendations on postmastectomy radiation support coordinated decision-making and patient-reported assessment while acknowledging important evidence gaps [25]. Although these recommendations are not specific to neurotization, they reinforce the need to consider sensory reconstruction within the patient's complete oncologic treatment pathway.

Evidence from a non-irradiated cohort cannot reliably quantify sensory outcomes after radiation. Likewise, mixed cohorts do not establish a radiation effect unless the relevant exposure and outcome are analyzed adequately. Proposed reporting requirements include distinguishing prior radiation from planned postoperative radiation and recording assessment timing relative to treatment completion. They do not imply that neurotization must be rejected whenever radiotherapy is required, nor that the graft is unaffected by it. They make explicit an unresolved question that remains important when interpreting current data.

The choice between autologous and implant reconstruction should take account of the wider clinical context and patient circumstances. The interim DIEP trial demonstrates why autologous sensory reconstruction warrants study [17], but its result cannot be used to claim that every patient should undergo a flap instead of an implant. Nor should a patient's interest in sensation alone settle a complex reconstructive choice. Discussion should integrate sensory goals with the available procedures, their burdens and contraindications, and the expected outcomes.

Patient-centered meaning and communication

The cohort reported by Shyu et al. [19] links sensory reconstruction with patient-reported well-being, but interpretation remains affected by treatment and reconstruction differences. Clinical assessment should establish whether patients experience a worthwhile change, rather than assigning the same value to any detectable touch. Patients should be invited to describe what matters to them, whether daily comfort, protective awareness, bodily ownership, or intimate sensation. These proposed domains are a counseling framework, not a claim that all were improved in every included study.

Communication should distinguish what is known, what is possible, and what remains uncertain. The explanation should cover the intended pathway, the possibility of incomplete recovery, the time needed for assessment, and the available alternatives. It should also explain that preserving the NAC does not guarantee sensation and that adding neurotization does not guarantee restoration to the preoperative experience. This approach translates the limitations of the evidence into understandable expectations while respecting how each patient weighs sensory function against other reconstructive priorities.

Protection from injury remains relevant during sensory recovery. Faulkner et al. [26] documented thermal injuries to reconstructed breasts from commonly used warming sources. These findings support counseling about the vulnerability of reconstructed skin, but do not establish that neurotization eliminates thermal injury risk. Improved touch thresholds should therefore not be taken to indicate normal temperature awareness. Until protective function is assessed appropriately, postoperative advice should reflect the actual clinical evaluation rather than the name of the operation.

Sensory recovery and neuropathic symptoms should also be assessed separately. The absence of reported neuromas or persistent dysesthesia in the series by Peled and colleagues [3, 11] is encouraging, but it is not proof that the procedure prevents chronic postmastectomy pain in a broader population. Trials should distinguish pain severity, location, character, and duration from tactile endpoints. This distinction avoids extending favorable sensory findings into claims about pain treatment that a study was neither designed nor powered to test.

Implementation and equitable access

The cost analysis by Boyd et al. [20] shows that additional resources can be substantial within one institution. The estimate should not be used to predict Polish reimbursement or treated as a universal market price. A meaningful economic evaluation would specify perspective, local prices, time horizon, comparator, and patient-valued outcomes. It should also account for the operative pathway actually used. These proposed criteria outline how value could be evaluated; this review does not provide a completed economic analysis of neurotization.

From a health-technology perspective, access may depend on surgical expertise, materials, follow-up infrastructure, and payment arrangements. The current evidence does not quantify inequity in access to NSM neurotization. Nonetheless, future implementation studies should examine whether referral distance,

affordability, and availability of sensory testing affect who receives the procedure and who contributes outcome data. Without such data, findings from a highly selected series may be generalized inappropriately to the wider patient population. Equity should therefore be investigated as a research question rather than assumed to be a benefit.

Responsible implementation should link innovation with data collection. Centers introducing the procedure could document the intended technique, intraoperative changes, sensory baseline, follow-up attendance, complications, and patient-reported experience using a common dataset. Although such a registry could not replace randomization for estimating causal benefit, it could characterize representativeness, uncommon harms, and delivery across settings. It would also document changes in operative technique, avoiding the grouping of several evolving procedures under a single, apparently stable intervention label.

Limitations of the evidence and of this review

Several limitations recur across the clinical literature: small samples, inconsistent controls, different sensory instruments, selected patient populations, evolving techniques, and incomplete follow-up. These limitations hinder direct comparison, even where studies consistently report improved sensation. The 2025 implant-focused review by Sorenson et al. [22] illustrates the relatively small and heterogeneous evidence base. Its pooled descriptive sample should not be added to the original series discussed here, since the patients are already represented in the underlying publications.

This review also has methodological limitations. It used one focused PubMed query and targeted supplementary retrieval rather than exhaustive searches across multiple databases. Selection was not performed independently by two reviewers, and no formal risk-of-bias tool was applied. Some claims had to be restricted to abstracts, while a recent randomized result was available only as a conference report. These methodological constraints may lead to omissions and selection bias. The resulting critical narrative interpretation cannot provide a definitive estimate of effectiveness or a comprehensive evidence map.

Potential overlap between publications from the same clinical program requires caution. A later report may contain some participants from an earlier cohort, extend follow-up, or measure additional endpoints. Patient counts should not be summed or presented as independent replication unless full study details exclude overlap. Similarly, repeated positive findings from one team do not constitute replication across several independent centers. This distinction should be maintained in future updates and in any quantitative synthesis.

Future research priorities

The priority for efficacy research is a comparison of a clearly defined sensory intervention with a contemporary non-neurotized operation, using the same reconstruction type and standardized assessment. Allocation, assessor blinding where feasible, primary endpoint, and follow-up duration should be specified before recruitment. Sample size should be based on a clinically justified between-group difference, and the analysis should account for bilateral and repeated observations. The small report by Hemal et al. [6] supports the feasibility of paired randomization but cannot resolve the question of efficacy.

Studies should also separate preservation alone from reconstruction when clinically possible. A comparison of combined preservation and grafting with standard NSM may demonstrate the value of a bundle without identifying which element contributes most. Such a result can still be clinically useful, provided that the claim applies to the combined intervention. Additional work could examine anatomical feasibility, graft type, distal target, and staged versus immediate reconstruction, without presenting uncontrolled comparisons as evidence of the superiority of a particular technical variant.

Research on patient-reported outcomes should prespecify what constitutes a worthwhile change and account for baseline expectations. Whole-person outcomes need careful interpretation in split-chest designs because the patient experiences both breasts together. Longer-term studies should link sensory outcomes with complications and oncologic information, rather than treating these as unrelated datasets. Economic and access evaluations should be conducted in the settings where the procedure is implemented. These steps would help connect technical innovation with reproducible evidence of patient benefit and responsible delivery.

Conclusions

Nerve preservation and NAC neurotization offer a plausible and increasingly studied route toward functional reconstruction after NSM. Early series and comparative observational research report encouraging sensory outcomes, while related randomized flap research supports the broader rationale for sensory nerve coaptation. Evidence directly addressing implant-based NAC neurotization remains heterogeneous, and the available small randomized conference report did not demonstrate a significant advantage. Current findings support careful evaluation and transparent discussion, without justifying a guarantee of normal sensation.

Every sensory maneuver must remain within the boundaries set by the required oncologic resection. Recorded postoperative morbidity, sensory efficacy, patient-reported benefit, and cancer safety are separate questions. Sensory reconstruction should be evaluated as a patient-centered intervention, with its value determined by both measurable recovery and what that recovery means to the individual.

Ethics approval. This narrative review uses published literature and introduces no new participant-level data or experiments. No new human or animal research was conducted for this draft.

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