

# Nipple-Areolar Complex Ischemia After Nipple-Sparing Mastectomy With Immediate Implant-Based Reconstruction: Risk Factors and the Success of Conservative Treatment

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## Abstract

**Background:** Nipple-sparing mastectomy performed via an inframammary fold incision with implant-based reconstruction is an oncologically safe procedure that provides excellent cosmesis.

**Objectives:** The authors report their experience with conservative treatment of postoperative nipple-areolar complex (NAC) ischemia and an analysis of risk factors for NAC ischemia and conservative treatment failure.

**Methods:** A retrospective chart review was conducted of 318 nipple-sparing mastectomies performed through inframammary fold incisions with implant-based reconstruction between July 2006 and October 2012. NAC dressings consisted of topical nitroglycerin, external warming for 24 hours, antibacterial petrolatum gauze, and a loose bra for 1 week. Patients were monitored for NAC ischemia as the primary endpoint. NAC ischemia was treated with bacitracin ointment. In cases of full-thickness ischemia, expanders were also partially deflated.

**Results:** Partial- and full-thickness NAC ischemia occurred in 44 (13.8%) and 21 (6.6%) cases, respectively. All partial- and 17 full-thickness cases resolved with conservative treatment. Of these, 7 partial- and 2 full-thickness cases suffered residual depigmentation. Four full-thickness cases required operative debridement. Factors associated with NAC ischemia included increasing age ( $P = .035$ ), higher body mass index ( $P = .0009$ ), greater breast volume ( $P = .0023$ ), and diabetes ( $P = .0046$ ). Factors associated with conservative treatment failure included increasing age ( $P < .0001$ ), higher body mass index ( $P = .014$ ), greater breast volume ( $P = .020$ ), smoking ( $P = .0449$ ), acellular dermal matrix use ( $P < .0001$ ), and single-stage reconstruction ( $P = .0090$ ).

**Conclusions:** Postoperative NAC ischemia can be effectively managed conservatively to preserve cosmesis and implant viability. Knowledge of risk factors for NAC ischemia and conservative treatment failure may improve future patient counseling and outcomes.

## Level of Evidence: 4

## Keywords

breast reconstruction, implants, tissue expanders, complications, inframammary fold, nipple-sparing mastectomy, implant-based reconstruction, nipple-areolar complex, conservative treatment, ischemia



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Numerous studies have now documented the oncologic safety of nipple-sparing mastectomy (NSM) in carefully selected patients with a negative retroareolar biopsy and a tumor more than 1 cm from the nipple-areolar complex (NAC).<sup>1-3</sup> Recently, Spear et al systematically reviewed the literature from 1970 to 2013 and documented the oncologic efficacy of NSM performed, with an acceptable complication

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profile and aesthetically pleasing outcomes.<sup>4</sup> For women struggling with the psychological obstacle of losing their breasts, the option to undergo an NSM can offer significant relief and improve cosmetic results.<sup>5</sup> With the advent of NAC preservation, oncologic surgeons, plastic surgeons, and patients should collaborate to discuss surgical resection, reconstructive options, and incision techniques to optimize nipple viability.

A number of different incisions can be made when performing an NSM, including radial incisions of various orientations, periareolar incisions, and inframammary fold (IMF) incisions.<sup>6,7</sup> No current studies document an optimal incision for NAC preservation, but in our experience, performing NSM through an IMF incision provides excellent cosmesis by hiding the scar in a natural crease and offers a high level of patient satisfaction. However, this approach also requires extensive undermining of the NAC, which may compromise its blood supply and result in increased rates of ischemia and depigmentation.

Postoperative NAC ischemia occurs in anywhere from 2.5% to 60% of cases of NSM.<sup>8-12</sup> According to current literature, patients known to be at higher risk for mastectomy flap ischemia include smokers,<sup>9</sup> older patients,<sup>11</sup> patients with higher body mass indices (BMI),<sup>13</sup> patients with greater breast volumes,<sup>13</sup> and patients who have undergone periareolar mastectomy incisions involving more than a third of the NAC circumference.<sup>6,9,10,12</sup> The most appropriate approach when NAC ischemia occurs remains to be determined; recommended treatment regimens range from conservative wound care to early operative debridement.<sup>14-16</sup>

In this article, we report a single surgeon's (M.T.) experience with postoperative NAC ischemia following NSM through an IMF incision with immediate implant-based reconstruction (IBR) and her success with conservative treatment measures. We also comment on risk factors that may have predisposed individual patients both to NAC ischemia and to conservative treatment failure.

## METHODS

A retrospective chart review was conducted on a prospectively collected, institutional review board–approved database of 318 women who underwent NSM via an IMF incision with either single- or 2-stage IBR as performed by a single plastic surgeon at a tertiary care academic medical center between July 2006 and October 2012. Both therapeutic and prophylactic NSM patients were included in the database. No patient was excluded because of demographic factors, risk factors, oncologic burden, or postoperative results. NSM was not offered to patients with grade 3 ptosis or a cup size greater than C. This study received approval from the Weill Cornell Medical College Institutional Review Board (No. 1207012728A001).

All reconstructions were performed by the senior author, whereas the mastectomies were performed by a number of different breast surgeons. All NSM were performed with the same technique. Breast skin flaps were infiltrated with 30 mL of local anesthetic consisting of 0.25% bupivacaine and 1% lidocaine with 1:100,000 epinephrine in a 1:1 ratio. An incision approximately 12 cm in length was made along the IMF. With a traction suture in the nipple, subdermal dissection was carried out with sharp scissors in a plane akin to a facelift, leaving a flap approximately 3 to 5 mm thick. The NAC was inverted and sharply cleaned of glandular tissue; the gland was then resected off the pectoralis muscle via electrocautery.

All NSM cases were reconstructed through a standard submuscular approach, minimizing dissection of the pectoralis muscle's medial fibers. For each operation, the tissue expander or permanent implant was completely covered with either muscle or acellular dermal matrix (ADM). For a single-stage reconstruction, a permanent implant was placed submuscularly. If the coverage was insufficient, a strip of ADM was placed inferiorly as a sling for implant coverage. Single-stage reconstruction was reserved for patients with small-volume implants, optimal tissue quality, and minimal clinical or demographic comorbidity. For 2-stage reconstruction, a tissue expander was placed in standard fashion in a submuscular pocket and fully covered by the pectoralis major and serratus muscles. The tissue expanders placed in these patients were the McGhan 133 series (Allergan, Irvine, California). Base width rather than desired cup size dictated the expander size. In cases of poor muscle coverage, ADM was placed at the senior author's discretion. Most patients underwent between 2 and 3 expansions prior to exchange. Permanent implants from various manufacturers were available and selected according to the patient's aesthetic desires and the senior author's clinical judgment.

After implant placement, the skin was redraped over the breast mound, centering the NAC at the point of maximal projection. No mastectomy flaps were debrided intraoperatively, since an accurate assessment of flap ischemia was precluded by injection of tumescent solution. All NSM cases were drained with 10-French Jackson-Pratt drains (Cardinal Health, Dublin, Ohio) either until the 24-hour output was less than 30 mL or the patient was 2 weeks postoperative. All patients received intravenous antibiotics within 30 minutes of surgical incision, along with a 7-day course of oral antibiotics postoperatively.

All patients received the same postoperative dressing: an application of topical nitroglycerin and antibacterial petrolatum gauze to the NAC, a loose bra, and external warming with a low-intensity Bair-Hugger (Arizant, Eden Prairie, Minnesota) for the first 24 hours. Prior to hospital discharge, on the first or second postoperative day, a fresh

antibacterial petrolatum gauze was applied. Patients were instructed not to remove the dressing until the first follow-up visit, approximately 1 week postoperatively.

During subsequent postoperative visits, all patients were assessed solely by the senior author. NAC ischemia was qualitatively determined by physical examination, including capillary refill, color, temperature, and turgor, rather than appraisal with an objective metric scale of nipple viability. Nipple/areola sensibility was not assessed. Based on this cumulative qualitative assessment of NAC viability, patients were stratified into 3 subgroups: normal healing, partial-thickness ischemia, or full-thickness ischemia. Patients with partial-thickness NAC ischemia began twice-daily applications of topical bacitracin ointment until their ischemia resolved. Patients with areas of full-thickness NAC ischemia underwent partial deflation of their tissue expander to a volume of 100 cc and began twice-daily applications of topical bacitracin ointment until their ischemia resolved. Tissue expansion was resumed with ischemic resolution. Patients underwent operative debridement only in the event of significantly compromised flap viability or implant exposure. For patients with normal wound healing, dressings were discontinued at the first postoperative visit, and expansion was begun. Final expansion was usually achieved within 6 weeks.

Whenever possible, patients were followed monthly for at least 1 year, with NAC ischemia as the primary endpoint. Postoperative aesthetic satisfaction was based on subjective patient verbal feedback (ratings of excellent, good, fair, or poor).

Statistical analysis was performed on a number of patient demographic and medical factors in an attempt to identify potential risk factors for both NAC ischemia and conservative treatment failure. Evaluated factors included patient age (elderly > 65 years), BMI (obesity > 30), breast volume, smoking status (active or former), diabetes (controlled with diet, oral hypoglycemic agents, or insulin), history of chest wall or breast radiation, history of lumpectomy, single stage reconstruction, and ADM placement. An unpaired Student *t*-test analyzed all continuous variables, and *P* values and 95% confidence intervals were reported. A chi-squared test determined all binary outcomes, and *P* values were reported.

## RESULTS

### Surgical Indications and Technique

From July 2006 to October 2012, 318 NSM through IMF incisions with IBR were performed. Surgical indications included invasive ductal carcinoma (*n* = 93, 29.2%), invasive lobular carcinoma (*n* = 23, 7.2%), a combination of invasive ductal and invasive lobular carcinoma (*n* = 3,

0.9%), ductal carcinoma in situ (*n* = 47, 14.8%), lobular carcinoma in situ (*n* = 10, 3.1%), a combination of ductal carcinoma in situ and lobular carcinoma in situ (*n* = 8, 2.5%), and prophylaxis (*n* = 134, 42.1%). An average of 573 cc of breast tissue was resected per breast during NSM (range, 11-2256 cc). Fifty-one cases (16.0%) underwent reconstruction with single-stage operations and permanent silicone or saline implant placement; 267 cases (84.0%) had 2-stage operations and tissue expander placement. ADM was placed in 27.0% (*n* = 86) of all cases: 48 of the 51 (94.1%) single-stage reconstructions and 38 of the 267 (14.2%) 2-stage reconstructions. Among cases with single-stage reconstruction, the average permanent implant size was 397 cc (range, 120-750 cc). Among cases with 2-stage reconstruction, the average final permanent implant size was 467 cc (range, 180-800 cc).

### Patient Characteristics

Average patient age was 47 years (range, 25-76 years). Average patient BMI was 21.5 (range, 16.1-38.1). Seven (2.2%) were current smokers, and 98 (30.1%) were former smokers. Any patient with a past smoking history was considered a former smoker, regardless of cessation date. Six cases (1.9%) had a history of diabetes mellitus: 2 with insulin-dependent Type 1 diabetes and 4 with diet-controlled Type 2 diabetes. Twenty-nine cases (9.1%) had undergone prior radiation to the ipsilateral breast or chest wall. Previous ipsilateral lumpectomies had been performed in 122 cases (38.4%). Patients were followed for an average of approximately 447 days, with an approximate range of 7 to 1897 days. The single patient who was followed for only 7 days was an international patient non-compliant with routine postoperative visits.

### Rates of Ischemia

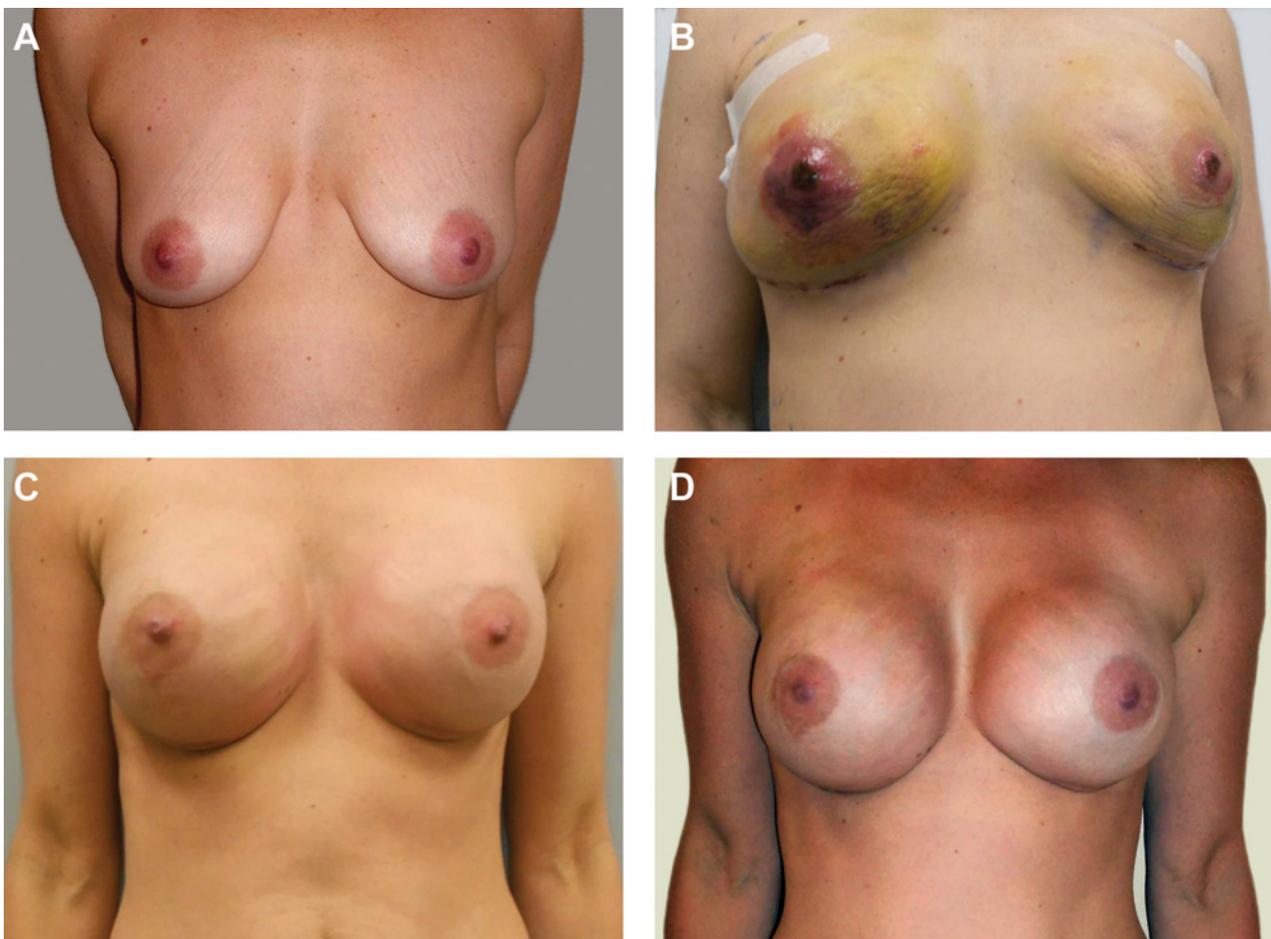
Partial-thickness NAC ischemia occurred in 44 of 318 cases (13.8%), all of which resolved with conservative treatment measures (Table 1). Of these, 37 (84.1%) healed without any residual NAC scar or depigmentation (Figure 1), and 7 (15.9%) were left with some degree of permanent NAC depigmentation. Full-thickness NAC ischemia occurred in 21 of 318 cases (6.6%; Table 1). Of these, 15 (71.4%) healed by secondary intention with conservative treatment measures (Figure 2); 2 (9.5%) healed with conservative treatment measures but were left with some permanent NAC depigmentation (Figure 3); and 4 (19.0%) ultimately required operative debridement and explantation. As of publication, all 4 of these cases are currently awaiting further reconstruction. The majority of patients reported good to excellent cosmetic results, with only 7 cases (2.2%) in which patients felt they had fair or poor results.

**Table 1.** Ischemia Rates and Response to Treatment, No. (%)

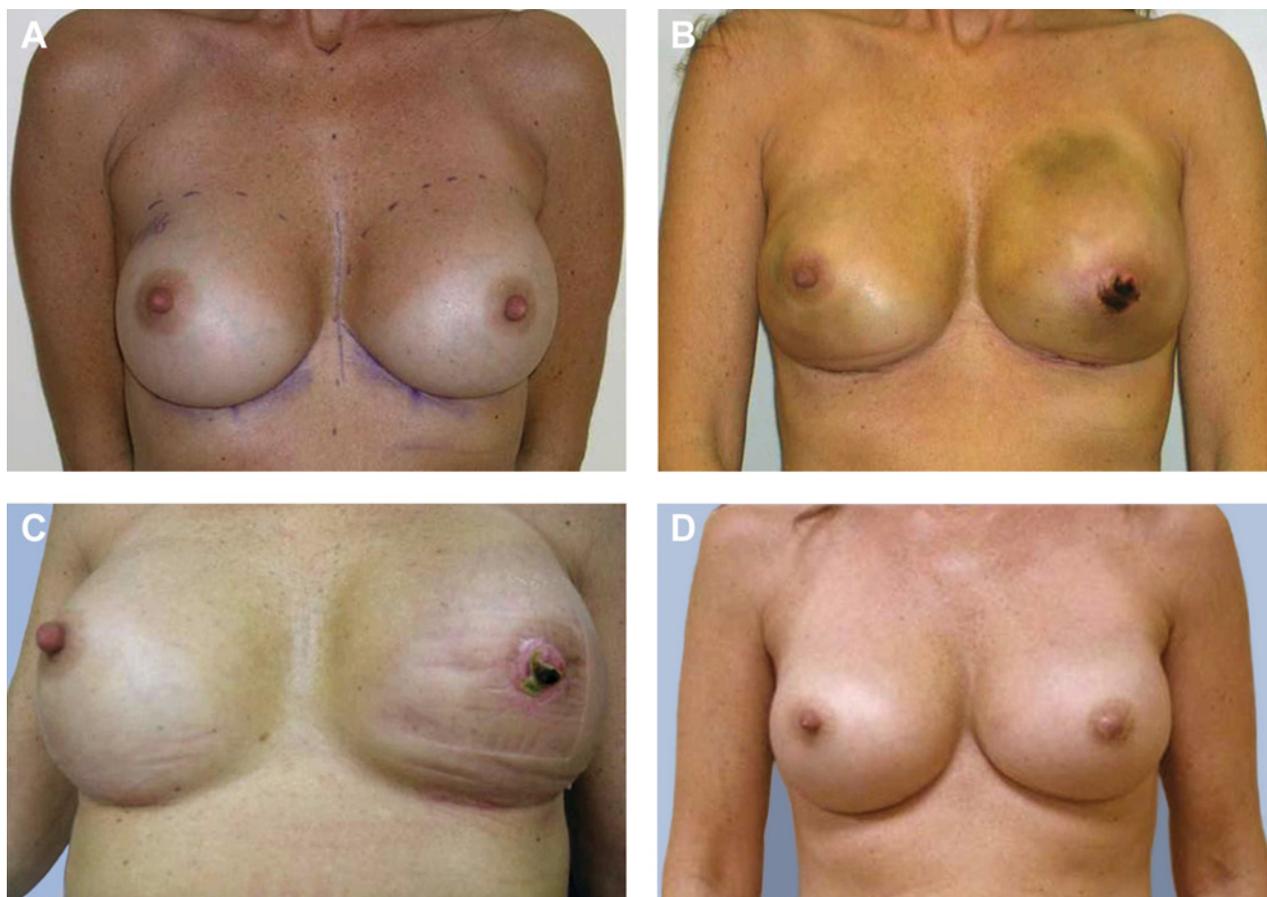
Treatment	NAC Ischemia		
	All Types	Partial Thickness	Full Thickness
No. (rate overall) <sup>a</sup>	65 (20.4)	44 (13.8)	21 (6.6)
Required operative debridement/explant	4 (6.2)	0 (0.0)	4 (19.0)
Resolved with conservative treatment	61 (93.8)	44 (100.0)	17 (81.0)
With NAC depigmentation	9 (13.8)	7 (15.9)	2 (9.5)
Without NAC depigmentation	52 (80.0)	37 (84.1)	15 (71.4)

Abbreviation: NAC, nipple-areolar complex.

<sup>a</sup>From N = 318. Percentage values in remaining rows are based on column value.



**Figure 1.** (A) This 34-year-old woman was a former smoker who suffered right-sided partial-thickness ischemia following bilateral prophylactic NSM with tissue expander reconstruction in the setting of *BRCA1* mutation; (B) 1 week after NSM, with partial-thickness ischemia; (C) 9 weeks after NSM, with complete ischemic resolution prior to tissue expander exchange; and (D) 7 months after NSM, which was 5 months after final breast reconstruction with placement of Natrelle Style 20 450cc silicone implants (Allergan, Inc, Irvine, California), with complete resolution of ischemia.



**Figure 2.** (A) This 49-year-old woman had a history of prior subpectoral breast augmentation with saline implants followed by bilateral NSM for right-sided ductal carcinoma in situ. She underwent single-stage reconstruction with placement of Natrelle Style 20 475cc silicone implants (Allergan, Inc, Irvine, California) and without acellular dermal matrix and suffered left-sided full-thickness ischemia. The final result followed ischemic resolution: (B) 1 week after NSM, with full-thickness ischemia; (C) 4 weeks after NSM, with full-thickness ischemia; and (D) 7 weeks after NSM, with complete ischemic resolution.

### Risk Factors for Ischemia

Higher rates of NAC ischemia were found with increasing age ( $P = .035$ ), increasing BMI ( $P = .0009$ ), greater breast volume ( $P = .0023$ ), or a history of diabetes mellitus ( $P = .0046$ ) (Table 2). Conversely, factors that had no apparent impact on NAC ischemia incidence included smoking status, radiation history, history of lumpectomy, ADM placement, and single-stage reconstruction (Table 3). Furthermore, clinical pathology or tumor staging did not statistically influence NAC ischemia incidence.

### Risk Factors for Conservative Treatment Failure

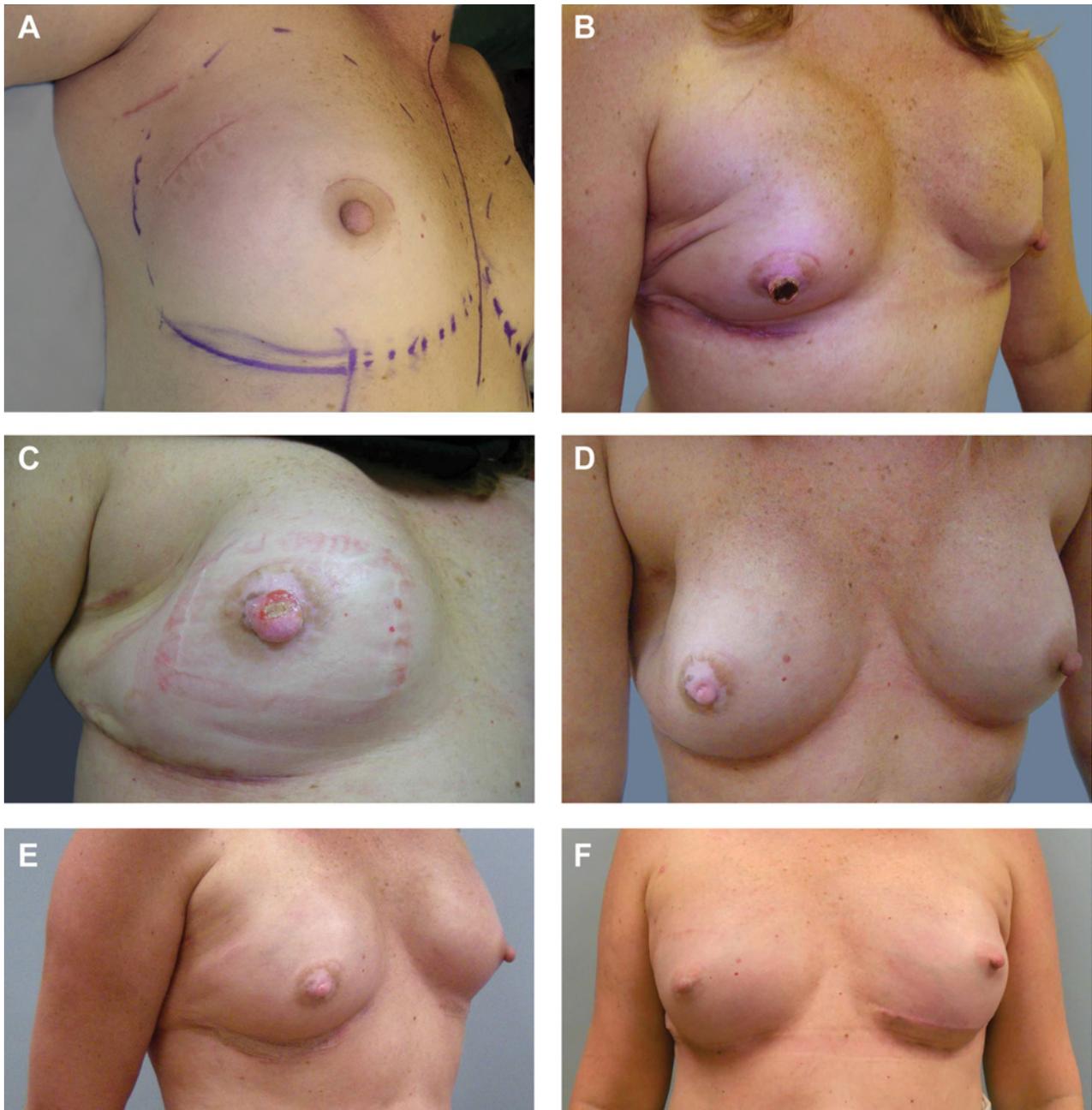
Among patients who suffered postoperative NAC ischemia, significantly higher rates of conservative treatment failure were seen with increasing age ( $P < .0001$ ), increasing BMI ( $P = .014$ ), greater breast volume resected ( $P = .020$ ),

current smoking ( $P = .0449$ ), ADM placement ( $P < .0001$ ), and single-stage reconstruction ( $P = .0090$ ) (Table 4). No significant difference in response to conservative treatment measures was found when cases were compared by history of diabetes, radiation, or prior lumpectomy (Table 5).

## DISCUSSION

### Treatment of NAC Ischemia

Ischemic NAC complications after NSM occur in 2.5% to 60% of all patients, with rates varying significantly by institution and by individual surgeon, depending on patient selection criteria, operative technique, and other factors.<sup>8-12</sup> Our reported rate of 20.4% is consistent with this range. Of note, 95.9% of our cases responded to conservative management with complete resolution of NAC ischemia; 9 of 318 (2.8%) had permanent NAC depigmentation; and 4 of 318 (1.3%) required operative debridement. According to



**Figure 3.** (A) This 44-year-old woman, a former smoker, suffered right-sided full-thickness ischemia after tissue expander reconstruction; she had a history of bilateral lumpectomies following bilateral NSM for right-sided invasive ductal carcinoma. Final reconstruction included placement of Natrelle Style 20 600cc silicone implants (Allergan, Inc, Irvine, California) after resolution of ischemia with persistent right sided depigmentation: (B) 1 week after NSM, with full-thickness ischemia; (C) 2 weeks after NSM, with full-thickness ischemia; (D) 12 weeks after NSM, prior to tissue expander exchange, with resolution of ischemia with persistent depigmentation; (E) persistent depigmentation 11 months after NSM and 6 months after final reconstruction with permanent implants; (F) persistent depigmentation 5 years after NSM.

current literature, patients known to be at higher risk for mastectomy flap ischemia include smokers,<sup>9</sup> older patients,<sup>11</sup> patients with higher BMI,<sup>13</sup> patients with greater breast volumes,<sup>13</sup> and patients who have undergone periareolar mastectomy incisions involving more than a third of the NAC

circumference.<sup>6,9,10,12</sup> Our retrospective review explored these risk factors and found similar associations.

Different approaches have been identified for treating mastectomy skin flap ischemia; however, there are no current recommendations for treating NAC ischemia secondary

**Table 2.** Patient Factors Associated With Higher Rates of Nipple-Areolar Complex Ischemia

Ischemia	Age (y)		Body Mass Index		Breast Volume Resected (cc)		Diabetes	
	$\mu$ (95% CI)	<i>P</i>	$\mu$ (95% CI)	<i>P</i>	$\mu$ (95% CI)	<i>P</i>	Rate (%)	<i>P</i>
No	46.5 (45.25, 47.81)	.035	21.22 (20.87, 21.57)	.0009	536.6 (485.5, 587.7)	.0023	0.79	.0046
Yes	49.6 (47.05, 52.09)		22.53 (21.85, 23.22)		712.9 (612.2, 813.8)		6.15	

Abbreviations: CI, confidence interval;  $\mu$ , mean value.

**Table 3.** Patient Factors Not Associated With Higher Rates of Nipple-Areolar Complex Ischemia

Ischemia	Current Smoking		ADM Use		Prior Radiation		Prior Lumpectomy		Single-Stage Reconstruction	
	Rate (%)	<i>P</i>	Rate (%)	<i>P</i>	Rate (%)	<i>P</i>	Rate (%)	<i>P</i>	Rate (%)	<i>P</i>
No	1.58	.1370	28.85	.1517	9.09	1.0719	36.36	.1477	17.39	.1944
Yes	4.62		20.00		9.23		46.15		10.77	

Abbreviation: ADM, allogeneic acellular dermal matrix product.

**Table 4.** Patient Factors Associated With Higher Rates of Conservative Treatment Failure: Nipple-Areolar Complex Ischemia

Conservative Treatment	Age (y)		Body Mass Index		Breast Volume Resected (cc)		Current Smoking		ADM Use		Single-Stage Reconstruction	
	$\mu$ (95% CI)	<i>P</i>	$\mu$ (95% CI)	<i>P</i>	$\mu$ (95% CI)	<i>P</i>	Rate (%)	<i>P</i>	Rate (%)	<i>P</i>	Rate (%)	<i>P</i>
Successful	48.2 (46.10, 50.40)	< .0001	22.24 (21.31, 23.17)	.014	677.1 (556.2, 798.1)	.020	3.28	.0449	14.75	< .0001	8.20	.0090
Failed; required explant	69.8 (61.35, 78.15)		26.98 (23.35, 30.60)		1259.0 (786.8, 1731)		25.00		100.00		50.00	

Abbreviations: ADM, allogeneic acellular dermal matrix product; CI, confidence interval;  $\mu$ , mean value.

to implant reconstruction. In 1989, Woods and Meland proposed that conservative management of nipple ischemia after subcutaneous mastectomy would maximize viability and outcomes while minimizing the need to expose patients to physical and psychological stresses of aggressive interventions.<sup>14</sup> In 2012, Patel et al described local wound care followed by delayed scar excision and/or revision as a functionally and cosmetically effective treatment for massive skin flap ischemia (defined as > 30% of the surface area) in mastectomy patients who had undergone autologous breast reconstruction.<sup>15</sup> Alternatively, in 2009, Antony et al argued that timed surgical debridement performed during continued serial expansions was appropriate in the setting of mastectomy flap ischemia.<sup>16</sup> However, our senior author's outcomes strongly suggest that NAC ischemia can be managed with conservative treatment measures, yielding excellent results and causing minimal patient distress.

As outlined previously, we recommend application of topical nitroglycerin and antibacterial petrolatum gauze to the NAC, a loose bra, and 24 hours of external warming. In the event of either partial- or full-thickness ischemia, we recommend delaying further expansion and beginning twice-daily applications of bacitracin ointment to the

affected area. The ointment can be discontinued and the expansion resumed with resolution of the ischemia. In addition, in cases of full-thickness ischemia, we recommend that tissue expanders be deflated to a maximum volume of 100 cc.

Our postoperative dressing combines previously reported recommended techniques for preventing ischemic NAC and skin flap complications. In 2010, Kutun et al published a prospective randomized controlled study documenting effectiveness of topical nitroglycerin in preventing skin flap ischemia after modified radical mastectomy.<sup>17</sup> Application of antibacterial petrolatum gauze not only provides some antibacterial protection but also helps maintain a moist environment that favors more rapid wound reepithelialization.<sup>18</sup> To preserve this sterile surgical site and decrease bacterial colonization surrounding the NAC, all while maintaining the moist wound healing environment, we kept the initial postoperative dressing in place for 1 week.<sup>19</sup>

While minimal evidence validates placement of external warming devices in mastectomy patients with immediate IBR, we recommend these devices in the immediate postoperative period. By increasing the ambient temperature in the area surrounding the skin flap, our hope is that the

**Table 5.** Patient Factors Not Associated With Higher Rates of Conservative Treatment Failure: Nipple-Areolar Complex Ischemia

Conservative Treatment	Diabetes		Prior Radiation		Prior Lumpectomy	
	Rate (%)	<i>P</i>	Rate (%)	<i>P</i>	Rate (%)	<i>P</i>
Successful	4.92	.1054	8.20	.2607	45.90	.8753
Failed; required explant	25.00		25.00		50.00	

resulting local vasodilation will decrease the risk of skin flap ischemia and necrosis. Careful attention must certainly be paid to avoid any thermal injury to the patient.<sup>20</sup>

Our treatment of NAC ischemia involves a mix of previously reported proposals for preventing ischemic NAC and skin flap complications. In their conservative management recommendations, Woods et al also endorsed application of both antibacterial petrolatum gauzes and topical antibiotic ointments.<sup>14</sup> Patel et al similarly advocated application of moisturizing gels and topical antibiotic ointment for skin flap ischemia.<sup>15</sup> Our recommendation to partially deflate tissue expanders in the event of NAC ischemia is based on observation that cutaneous blood flow increases whenever expanded tissues are placed under less tension. This significant increase in cutaneous blood flow seen with tissue expander deflation has been quantified in numerous animal models.<sup>21,22</sup>

### Risk Factors for Ischemia and Conservative Treatment Failure

We found that NAC ischemia was significantly associated with increasing age, increasing BMI, greater breast volume, and a history of diabetes (Tables 2 and 3). Among patients who suffered postoperative NAC ischemia, significantly higher rates of conservative treatment failure were seen with increasing age, increasing BMI, greater breast volume resected, current smoking, ADM placement, and single-stage reconstruction (Tables 4 and 5).

Our identified risk factors for NAC ischemia reflect the findings of recent skin flap ischemia studies. Increasing age, increasing BMI, greater breast volume, and diabetes have previously been associated with higher rates of mastectomy flap ischemia.<sup>13,23</sup> These patient populations tend to have a higher burden of medical comorbidities that compromise wound healing. Older patients and those with diabetes typically have significant microvascular disease decreasing skin flap perfusion and delaying wound maturation. Anatomically, higher BMI and larger-breasted patients have larger mastectomy flaps—and, thus, a greater risk of compromised NAC perfusion.

ADM placement and consequent increased risk of NAC or skin flap ischemia are the subject of conflicting reports.

A 2012 study by Weichman et al found significantly higher rates of skin flap ischemia requiring excision ( $P = .015$ ) in patients reconstructed with ADM.<sup>24</sup> Conversely, numerous other studies have failed to find any significant difference in skin flap ischemia rates with and without ADM placement.<sup>25-28</sup>

Despite a small sample of cases in which conservative treatment measures failed ( $n = 4$ ), significant risk factors were identified for failure of conservative treatment (Tables 4 and 5). As discussed previously, increased risk of conservative treatment failure in older and more overweight patients may be a function of their medical comorbidities and poor wound healing, as well as the presence of larger mastectomy flaps in patients with higher BMI. Previous studies have documented the safety and efficacy of single-stage implant reconstruction with and without ADM application.<sup>25,29</sup> Our incidence of NAC ischemia is consistent with the reported literature. NAC ischemia in single-stage implant reconstruction can result from the relatively larger implant exerting greater tension on the mastectomy flap, as well as the surgeon's inability to deflate the permanent implant in office to allow for NAC healing under reduced tension. The association between ADM placement and conservative treatment failure may be solely a function of more frequent ADM application in single-stage reconstruction cases. Alternatively, the presence of a foreign body may increase infection risk and thereby compromise NAC viability. Given the small sample size of 2-stage reconstruction cases in which ADM was placed, we could not formulate a multivariate analysis of staged reconstruction with ADM—and could not thereby evaluate the resulting impact on NAC ischemia. Finally, multiple reports exist in the literature documenting smoking's detrimental effects on wound healing secondary to compromised tissue perfusion and microvascular disease; we are not surprised to find such an association in our own statistical analysis.<sup>9</sup>

### Limitations and Future Directions

There are certainly limitations to our study. The study was a retrospective chart review of patients of a single plastic surgeon operating at a single large tertiary care academic medical center; as such, the results may not be generalizable

to all surgeons and all institutions across the country. The senior author worked with a number of breast surgeons, who have different techniques and experiences. Since we did not perform individual subgroup analysis on our results according to the breast surgeon, we cannot account for how differing breast surgeon techniques and experience influenced ischemic rates or treatment outcomes; however, in many ways, our analysis is probably best representative of most medical centers. Furthermore, all patients underwent NSM with an IMF incision and immediate IBR, per our inclusion criteria; the study does not seek to compare ischemia and treatment results from either different surgical approaches to NSM or different reconstructive approaches. Our oncologic surgeons used tumescent solution and nipple coring as integral aspects of their surgical technique, which could influence NAC viability because of their inherent ischemic effects. Secondary to oncologic necessity and the surgical techniques of the breast surgeons, these 2 variables could not be evaluated against a control as potential risk factors for NAC ischemia. We encourage others to further investigate any and all of these areas. Finally, we did not attempt to compare conservative treatment with either a control group or an alternative treatment group; consequently, we cannot claim that conservative treatment is necessarily superior to other approaches but only that it has worked well in our experience. Given the serious complication profile associated with NAC ischemia progression—including nipple malposition, wound dehiscence, and possible implant exposure—a control group was not feasible in this study.

All scoring of ischemia and its response to treatment was subjective and determined by the senior author. Currently, no standard exists to assess NAC ischemia after NSM, and the diagnosis certainly represents a continuum of severity. In theory, partial-thickness injuries should always heal with conservative wound care, since they do not extend the entire thickness of the dermis<sup>30</sup>; in contrast, full-thickness injuries, in which the entire dermis is involved, should have permanent sequelae.<sup>30</sup> Nevertheless, in this study, we found that some cases of partial-thickness ischemia would in fact progress. Conversely, many injuries that appeared to be more severe would heal when treated conservatively. That we cannot always predict an ischemic injury's progression points to the limitations inherent in a purely subjective scoring of tissue ischemia. Technologies that aid in ischemia diagnosis are currently in development, such as the SPY Elite System (LifeCell, Bridgewater, New Jersey). A 2010 study by Komorowska-Timek and Gurtner showed a significant decrease in ischemic complications from 15.1% to 4% ( $P < .01$ ) after laser-assisted indocyanine green perfusion mapping was performed intraoperatively and high-risk tissue was resected prophylactically at the time of surgery.<sup>31</sup> Newman et al similarly employed laser-assisted indocyanine green perfusion

mapping to assess mastectomy flap perfusion intraoperatively and found a 95% correlation between intraoperative perfusion mapping and subsequent clinical course.<sup>32</sup> Such technologies should allow for more prompt and appropriate tissue treatment based on objective assessment of ischemia severity.<sup>31,32</sup> Ultimately, these objective tools may define an NAC ischemia grading system and improve ischemic outcomes. Our senior author could not use this technology, because of the reported low efficacy of SPY angiography in conjunction with tumescent solution.

Despite these limitations, our study provides anecdotal evidence of successful conservative treatment measures in managing postoperative NAC ischemia in patients who have undergone NSM through an IMF incision with immediate IBR. Furthermore, it provides statistically significant data about potential risk factors for ischemia and for poor responses to conservative treatment. These data can certainly be applied in selecting appropriate surgical candidates, in perioperative counseling of patients, and in determining the most appropriate treatment for NAC ischemia.

## CONCLUSIONS

NSM via an IMF incision followed by immediate IBR offers a reasonable option for patients undergoing therapeutic or prophylactic mastectomies. Patients should be made aware of the potential for ischemic wound-healing problems associated with this procedure. NAC ischemia or depigmentation can be a devastating complication, but our experience indicates that prolonged conservative management with local wound care is an appropriate treatment to preserve cosmesis and implant viability. In our study, despite an NAC ischemia rate of 20.4%, only 2.8% of overall cases were left with any permanent NAC depigmentation after conservative treatment efforts, and only 1.3% of overall cases ultimately required operative debridement and explantation. Patient factors associated with higher NAC ischemia rates included increasing age, increasing BMI, greater breast volume, and a history of diabetes. Finally, conservative treatment failure was significantly associated with increasing age, increasing BMI, greater breast volume, current smoking, ADM placement, and single-stage reconstruction.

## Authors' Note

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## Disclosures

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## REFERENCES

- Gerber B, Krause A, Dieterich M, Kundt G, Reimer T. The oncological safety of skin sparing mastectomy with conservation of the nipple-areola complex and autologous reconstruction: an extended follow-up study. *Ann Surg* 2009;249:461-468.
- Spear SL, Willey SC, Feldman ED, et al. Nipple-sparing mastectomy for prophylactic and therapeutic indications. *Plast Reconstr Surg* 2011;128:1005-1014.
- Fortunato L, Loreti A, Andrich R, et al. When mastectomy is needed: is the nipple-sparing procedure a new standard with very few contraindications [published online August 1, 2013]? *J Surg Oncol*.
- Endara M, Chen D, Verma K, Nahabedian M, Spear S. Breast reconstruction following nipple sparing mastectomy: a systematic review of the literature with pooled analysis. *Plast Reconstr Surg* 2013;132:1043-1054.
- Munhoz AM, Aldrighi CM, Montag E, et al. Clinical outcomes following nipple-areola-sparing mastectomy with immediate implant-based breast reconstruction: a 12-year experience with an analysis of patient and breast-related factors for complications [published online July 30, 2013]. *Breast Cancer Res Treat*.
- Moyer HR, Ghazi B, Daniel JR, Gasgarth R, Carlson GW. Nipple-sparing mastectomy: technical aspects and aesthetic outcomes. *Ann Plast Surg* 2012;68:446-450.
- Stolier AJ, Sullivan SK, Dellacroce FJ. Technical considerations in nipple-sparing mastectomy: 82 consecutive cases without necrosis. *Ann Surg Oncol* 2008;15:1341-1347.
- Radovanovic Z, Radovanovic D, Golubovic A, Ivkovic-Kapic T, Bokorov B, Mandic A. Early complications after nipple-sparing mastectomy and immediate breast reconstruction with silicone prosthesis: results of 214 procedures. *Scand J Surg* 2010;99:115-118.
- Algaithy ZK, Petit JY, Lohsiriwat V, et al. Nipple sparing mastectomy: can we predict the factors predisposing to necrosis? *Eur J Surg Oncol* 2012;38:125-129.
- Garwood ER, Moore D, Ewing C, et al. Total skin-sparing mastectomy: complications and local recurrence rates in 2 cohorts of patients. *Ann Surg* 2009;249:26-32.
- Komorowski AL, Zanini V, Regolo L, Carolei A, Wysocki WM, Costa A. Necrotic complications after nipple- and areola-sparing mastectomy. *World J Surg* 2006;30:1410-1413.
- Regolo L, Ballardini B, Gallarotti E, Scoccia E, Zanini V. Nipple sparing mastectomy: an innovative skin incision for an alternative approach. *Breast* 2008;17:8-11.
- Davies K, Allan L, Roblin P, Ross D, Farhadi J. Factors affecting postoperative complications following skin sparing mastectomy with immediate breast reconstruction. *Breast* 2011;20:21-25.
- Woods JE, Meland NB. Conservative management in full-thickness nipple-areolar necrosis after subcutaneous mastectomy. *Plast Reconstr Surg* 1989;84:258-264.
- Patel KM, Hill LM, Gatti ME, Nahabedian MY. Management of massive mastectomy skin flap necrosis following autologous breast reconstruction. *Ann Plast Surg* 2012;69:139-144.
- Antony AK, Mehrara BM, McCarthy CM, et al. Salvage of tissue expander in the setting of mastectomy flap necrosis: a 13-year experience using timed excision with continued expansion. *Plast Reconstr Surg* 2009;124:356-363.
- Kutun S, Ay AA, Ulucanlar H, et al. Is transdermal nitroglycerin application effective in preventing and healing flap ischaemia after modified radical mastectomy? *S Afr J Surg* 2010;48:119-121.
- Winter GD. Formation of the scab and the rate of epithelialization of superficial wounds in the skin of the young domestic pig. *Nature* 1962;193:293-294.
- Veiga-Filho J, Veiga DF, Sabino-Neto M, et al. Dressing wear time after reduction mammoplasty: a randomized controlled trial. *Plast Reconstr Surg* 2012;129:1e-7e.
- Zukowski ML, Lord JL, Ash K. Precautions in warming light therapy as an adjuvant to postoperative flap care. *Burns* 1998;24:374-377.
- Celet Ozden B, Guven E, Aslay I, et al. Does partial expander deflation exacerbate the adverse effects of radiotherapy in two-stage breast reconstruction? *World J Surg Oncol*. 2012;10:44.
- Goding GS, Cummings CW, Trachy RE. Tissue expansion and cutaneous blood flow. *Laryngoscope* 1988;98:919-922.
- Hultman CS, Daiza S. Skin-sparing mastectomy flap complications after breast reconstruction: review of incidence, management, and outcome. *Ann Plast Surg* 2003;50:249-255.
- Weichman KE, Wilson SC, Weinstein AL, et al. The use of acellular dermal matrix in immediate two-stage tissue expander breast reconstruction. *Plast Reconstr Surg* 2012;129:1049-1058.
- Colwell AS, Damjanovic B, Zahedi B, Medford-Davis L, Hertl C, Austen WG Jr. Retrospective review of 331 consecutive immediate single-stage implant reconstructions with acellular dermal matrix: indications, complications, trends, and costs. *Plast Reconstr Surg* 2011;128:1170-1178.
- Parks JW, Hammond SE, Walsh WA, Adams RL, Chandler RG, Luce EA. Human acellular dermis versus no acellular dermis in tissue expansion breast reconstruction. *Plast Reconstr Surg* 2012;130:739-746.
- Peled AW, Foster RD, Garwood ER, et al. The effects of acellular dermal matrix in expander-implant breast reconstruction after total skin-sparing mastectomy: results of a prospective practice improvement study. *Plast Reconstr Surg* 2012;129:901e-908e.

28. Vardanian AJ, Clayton JL, Roostaeian J, et al. Comparison of implant-based immediate breast reconstruction with and without acellular dermal matrix. *Plast Reconstr Surg* 2011;128:403e-410e.
29. Roostaeian J, Sanchez I, Vardanian A, et al. Comparison of immediate implant placement versus the staged tissue expander technique in breast reconstruction. *Plast Reconstr Surg* 2012;129:909e-918e.
30. Wasiak J, Cleland H, Campbell F, Spinks A. Dressings for superficial and partial thickness burns. *Cochrane Database Syst Rev* 2013;3: CD002106.
31. Komorowska-Timek E, Gurtner GC. Intraoperative perfusion mapping with laser-assisted indocyanine green imaging can predict and prevent complications in immediate breast reconstruction. *Plast Reconstr Surg* 2010;125:1065-1073.
32. Newman MI, Samson MC, Tamburrino JF, Swartz KA. Intraoperative laser-assisted indocyanine green angiography for the evaluation of mastectomy flaps in immediate breast reconstruction. *J Reconstr Microsurg* 2010;26:487-492.