Ann Surg Oncol (2012) 19:3402–3409
DOI 10.1245/s10434-012-2362-y

Annals of
SURGICAL ONCOLOGY
OFFICIAL JOURNAL OF THE SOCIETY OF SURGICAL ONCOLOGY

ORIGINAL ARTICLE – BREAST ONCOLOGY

Outcomes after Total Skin-sparing Mastectomy and Immediate Reconstruction in 657 Breasts

Anne Warren Peled, MD[1], Robert D. Foster, MD[1], Allison C. Stover, MPH[2], Kaoru Itakura, BA[2], Cheryl A. Ewing, MD[2], Michael Alvarado, MD[2], E. Shelley Hwang, MD, MPH[3], and Laura J. Esserman, MD, MBA[2]

[1]Division of Plastic and Reconstructive Surgery, Department of Surgery, University of California, San Francisco, CA;
[2]Department of Surgery, Carol Franc Buck Breast Cancer Center, University of California, San Francisco, CA;
[3]Department of Surgery, Duke University Medical Canter, Durham, NC

ABSTRACT

Background. Total skin-sparing mastectomy (TSSM), a technique comprising removal of all breast and nipple tissue while preserving the entire skin envelope, is increasingly offered to women for therapeutic and prophylactic indications. However, standard use of the procedure remains controversial as a result oft concerns regarding oncologic safety and risk of complications.

Methods. Outcomes from a prospectively maintained database of patients undergoing TSSM and immediate breast reconstruction from 2001 to 2010 were reviewed. Outcome measures included postoperative complications, tumor involvement of the nipple–areolar complex (NAC) on pathologic analysis, and cancer recurrence.

Results. TSSM was performed on 657 breasts in 428 patients. Indications included in situ cancer [111 breasts (16.9 %)], invasive cancer [301 breasts (45.8 %)], and prophylactic risk-reduction [245 breasts (37.3 %)]. A total of 210 patients (49 %) had neoadjuvant chemotherapy, 78 (18.2 %) had adjuvant chemotherapy, and 114 (26.7 %) had postmastectomy radiotherapy. Nipple tissue contained in situ cancer in 11 breasts (1.7 %) and invasive cancer in 9 breasts (1.4 %); management included repeat excision (7 cases), NAC removal (9 cases), or radiotherapy without further excision (4 cases). Ischemic complications included 13 cases (2 %) of partial nipple loss, 10 cases (1.5 %) of complete nipple loss, and 78 cases (11.9 %) of skin flap necrosis. Overall locoregional recurrence rate was 2 % (median follow-up 28 months), with a 2.4 % rate observed in the subset of patients with at least 3 years' follow-up (median 45 months). No NAC skin recurrences were observed.

Conclusions. In this large, high-risk cohort, TSSM was associated with low rates of NAC complications, nipple involvement, and locoregional recurrence.

Mastectomy with complete preservation of the skin envelope has been developed as an extension of skin-sparing mastectomy to improve aesthetic and psychological outcomes for patients. Nipple-sparing, or total skin-sparing, mastectomy techniques entail complete removal of all breast tissue with excision of the nipple tissue while preserving the entire skin envelope. The technique of total skin-sparing mastectomy (TSSM) is differentiated from subcutaneous mastectomy in that minimal, if any, nipple tissue is left behind. However, as with the initial reaction to skin-sparing mastectomy, there is still significant concern that preservation of the nipple–areolar complex (NAC) skin may increase locoregional recurrence rates. Although this concern has limited the widespread adoption of the technique, the recent publication of several studies with longer follow-up describing recurrence rates similar to those after skin-sparing mastectomy demonstrate that the technique does not appear to jeopardize oncologic safety.[1–3]

In addition to concerns for oncologic safety, the risk of increased postoperative complications has led to reluctance amongst some surgeons and institutions to adopt the technique. Complete preservation of the skin envelope after removal of the underlying breast and nipple tissue is reliant only on dermal blood supply, which puts the preserved NAC skin at heightened risk of ischemia, which can be

Presented at the 2011 San Antonio Breast Cancer Symposium, San Antonio, TX, December 2011.

First Received: 13 January 2012;
Published Online: 18 April 2012

L. J. Esserman, MD, MBA
e-mail: Laura.esserman@ucsfmedctr.org

further compromised with pressure from the underlying reconstruction. However, early reports on the technique did demonstrate high rates of ischemic complications such as nipple and mastectomy flap necrosis.[4–7] As techniques have evolved and improved, the rates of ischemic complications have been reduced to acceptable levels.[1,8,9]

Our group first began performing total skin-sparing mastectomies in 2001. In reviewing results from our early experience, we found an increased risk of NAC complications with periareolar incisions extending beyond one-third of the NAC diameter and with immediate permanent implant placement.[7] We subsequently modified our techniques and reconstructive approaches, with a significant reduction in complications.[8] As we have further refined our techniques, we have continued to serially review our postoperative complications and develop targeted interventions to attempt to further reduce complication rates. This study describes our 10-year experience with TSSM and immediate reconstruction and reports our oncologic outcomes and surgical complications.

METHODS

Patient Selection

Candidacy for TSSM evolved during the years in our study. Initially, only women who had no clinical evidence of nipple or skin involvement and underwent magnetic resonance imaging (MRI) preoperatively to confirm that there was no tumor within 2 cm of the NAC were eligible. However, as TSSM became an increasingly larger part of our group's practice, we found that routine preoperative MRI was not necessary, and instead now use it only in cases where the tumor is close to the nipple on clinical examination or mammography; if preoperative MRI demonstrates no clear tumor involvement of the NAC, patients are still eligible for TSSM, even if the tumor lies in close proximity (<1 cm) to the NAC. This evolution in selection criteria is based on the same standard that is used for performing skin-sparing mastectomy, which is to offer the technique to patients in whom we expect to be able to achieve clear surgical margins at the time of mastectomy. With our current eligibility criteria, we continue to exclude women with clinical evidence of nipple or skin involvement at the time of mastectomy, though we will perform TSSM in women initially presenting with tumor involvement of the skin who have a good response to neoadjuvant chemotherapy.

TSSM Technique

We have previously described the TSSM technique, which involves inversion of the nipple and complete excision of all nipple tissue at the dermal junction.[7,8] Incisions used included inframammary, lateral, radial, NAC crossing, superior areolar/mastopexy, and circumareolar (with free nipple grafting) incisions as well as nonspecific incisions incorporating prior breast surgery scars.

Reconstructive Technique

Standard autologous and prosthetic reconstructive options were offered to patients, including transverse rectus abdominis myocutaneous flaps, microvascular flaps, latissimus dorsi flaps with or without implants, two-stage expander-implant reconstruction, and immediate implant placement. Expander-implant reconstruction involves subpectoral placement of the expander with minimal (50–100 ml) intraoperative expander fill.

Oncologic and Surgical Outcomes

Prospective collection of clinical data from all TSSM cases was initiated in 2005, with retrospective review performed for cases from 2001 to 2004. This study was approved by the University of California, San Francisco Committee on Human Research.

Oncologic outcomes included locoregional and distant recurrences as well as NAC involvement. Recurrences were identified through medical records review and cross-referencing of data with the California Tumor Registry. NAC involvement was determined by serial sectioning of the removed nipple tissue during pathologic analysis.

Postoperative complications were meticulously collected through weekly meetings with the breast surgeons, plastic surgeons and clinic nurses to ensure complete and accurate real-time capture of all complications and unplanned procedures. Standardized definitions of data fields were created and reviewed with all research team members and interval database reviews were performed to ensure data accuracy. The complications included for analysis were wound infection, skin flap necrosis, expander-implant loss, and nipple necrosis. Infection was defined by localized or systemic evidence of infection that led to clinician prescription of oral antibiotics or admission for intravenous antibiotics. Skin flap necrosis was defined as any necrosis of the mastectomy skin flaps extending from a partial thickness level or deeper. Nipple necrosis was defined as any necrosis (partial or total) leading to visible loss of projection or contour of the nipple. Rates of complications were determined per breast. Complication rates were compared between the first 100 cases and the subsequent 557 cases by chi-square analysis to evaluate the impact of technical refinements in the initial learning period. Time to local or distant recurrence was analyzed by considering local recurrence and distant recurrence to be

competing events; thus, cumulative incidence of recurrence was determined by a cumulative incidence competing risks method.[10] Simultaneous local and distant recurrence was included as both a local and a distant recurrence in this analysis.

RESULTS

Patients

From January 2001 through December 2010, TSSM and immediate reconstruction was performed in 428 patients, 229 of whom (53.5 %) had bilateral mastectomies, for a total of 657 TSSM procedures. Mean patient age was 46.9 years (range 19–78.3 years). Mean body mass index was 24.1. Seven patients (1.6 %) were smokers.

Tumor and Treatment Characteristics

Indications for mastectomy, clinical tumor stage, and adjunct treatment are shown in Table 1. Of 245 prophylactic mastectomies, 58 (23.7 %) were bilateral; 38 (65.6 %) of these cases were done in known BRCA-1 or -2 mutation carriers, 6 (10.3 %) were done in patients with a personal history of atypia, and the rest (14 patients, 24.1 %) were done in patients with strong family histories of breast cancer who did not have documented genetic mutations, either because patients had tested negative for a genetic mutation or because they had chosen not to undergo testing. A total of 210 patients (49.1 %) received neoadjuvant chemotherapy and 78 (18.2 %) received adjuvant therapy; the high rate of neoadjuvant chemotherapy reflects our institution's preference to sequence chemotherapy before surgery in patients who have preoperative indications for chemotherapy to improve choices for surgical options. Postmastectomy radiotherapy was performed in 17.3 % of cases. A total of 158 patients (36.7 %) were treated with adjuvant hormonal therapy.

TABLE 1 Tumor and treatment characteristics

Characteristic	*n* (%)[a]
Indication for mastectomy	
Therapeutic	412 (62.7)
Prophylactic	245 (37.3)
Contralateral	187 (76.3)
Bilateral	58 (23.7)
Tumor stage	
0	111 (16.9)
I	136 (20.7)
II	96 (14.6)
III	48 (7.3)
IV	7 (1.1)
Type of surgery	
Prophylactic	245 (37.3)
Recurrent cancer	14 (2.1)
Chemotherapy	
Any	288 (67.3)
Neoadjuvant	210 (72.9)
Adjuvant	78 (27.1)
Radiotherapy	
Any	158 (24)
Prior history	44 (27.8)
Postmastectomy	114 (72.2)

[a] All rates determined per number of breasts, except for chemotherapy, which was determined per number of patients

Surgical Characteristics

Incisional approaches for TSSM are shown in Table 2. Over the 10-year period, the preferred incisions changed from a broad variety of incisions used in the first 100 cases to primarily superior areolar/mastopexy and inframammary incisions used for the next 557 cases, with no NAC crossing incisions or free nipple grafts performed after the first 100 cases. Types of reconstruction performed are shown in Table 3. Preferred reconstructive technique also changed over time, with no permanent implant reconstructions done after 2006 and over 90 % of reconstructions done with a 2-stage expander-implant technique since the first 100 cases.

Postoperative Complications

Rates of postoperative complications are shown in Table 4. Mastectomy skin flap necrosis occurred in 11.9 % of cases and wound infection occurred in 17.8 % of cases. Of the 563 cases of prosthetic reconstruction, 56 (9.9 %)

TABLE 2 TSSM incision

Incision	Cases, *n* (%)		
	First 100 cases	Next 557 cases	All cases
Inframammary	22 (22)	376 (67.5)	398 (60.6)
Superior areolar/mastopexy	14 (14)	116 (20.8)	130 (19.8)
Radial	36 (36)	11 (2)	47 (7.2)
Lateral	1 (1)	31 (5.6)	32 (4.9)
Nipple–areolar complex crossing	10 (10)	0 (0)	10 (1.5)
Circumareolar with free nipple graft	6 (6)	0 (0)	6 (0.9)
Other[a]	11 (11)	23 (4.1)	34 (5.2)

[a] Incisions designed to incorporate prior breast surgery scar

were complicated by expander-implant loss, which was significantly reduced after one-stage permanent implant placement was discontinued (25 % vs. 8.4 %, $P = 0.0009$). Nipple necrosis occurred in 23 cases (3.5 %), with only 10 cases (1.5 %) complicated by complete necrosis. Ischemic complications of the nipple greatly decreased after the technical refinements of minimizing the extent of periareolar incisions, no longer using free nipple grafts or NAC-crossing incisions, and performing prosthetic reconstruction in a two-stage fashion were instituted to target the high rates of nipple necrosis seen in our group's early experience with the technique.[8] Comparison of complication rates from the first 100 cases to the next 557 cases showed a reduction in rates of nipple necrosis from 13 % to 1.8 % ($P < 0.0001$).

TABLE 3 Reconstructions performed

Reconstruction	Cases, *n* (%)		
	First 100 cases	Next 557 cases	All cases
Two-stage expander-implant	23 (23)	510 (91.6)	533 (81.1)
Pedicle TRAM	29 (29)	31 (5.6)	60 (9.1)
Free TRAM/DIEP	16 (16)	11 (2)	27 (4.1)
Immediate permanent implant	29 (29)	1 (0.2)	30 (4.6)
Latissimus dorsi	1 (1)	2 (0.4)	3 (0.5)
Other microvascular	2 (2)	2 (0.4)	4 (0.6)

TRAM transverse rectus abdominis myocutaneous flap, *DIEP* deep inferior epigastric perforator flap

TABLE 4 Postoperative complications

Complication	Cases, *n* (%)		
	First 100 cases	Next 557 cases	All cases
Infection	14 (14)	103 (18.5)	117 (17.8)
Nipple necrosis	13 (13)	10 (1.8)	23 (3.5)
Partial	9 (9)	4 (0.7)	13 (2)
Complete	4 (4)	6 (1.1)	10 (1.5)
Mastectomy skin flap necrosis	15 (15)	63 (11.3)	78 (11.9)
Expander-implant loss[a]	13 (25)	43 (8.4)	56 (9.9)

[a] Rates calculated per number of prosthetic reconstructions performed ($n = 52$ for first 100 cases, $n = 511$ for next 557 cases)

Oncologic Outcomes

Final pathologic analysis demonstrated tumor in 20 (3 %) of nipple tissue specimens, 11 of which were in situ cancer and 9 invasive cancer. Management included repeat excision in 7 cases, NAC removal in 9 cases, and NAC radiation without additional surgical treatment in 4 cases (Fig. 1). Repeat excision and NAC removal were performed at the time of expander-implant exchange in patients who underwent prosthetic reconstruction or at the time of flap revision in patients who underwent autologous reconstruction. Nearly all patients with invasive cancer in the nipple specimen underwent NAC removal, with the exception of 1 patient who had a very small focus of tumor near the NAC skin margin who was highly motivated to preserve her NAC; repeat excision demonstrated complete replacement of the nipple core with fibrous scar. All of the 16 removed NAC and reexcised nipple tissue specimens were negative for residual tumor. Median follow-up for the entire group was 28 months (range 3 to 116 months). Locoregional recurrence alone occurred in 4 patients (1 %), distant recurrence alone occurred in 8 patients (1.9 %), and simultaneous locoregional and distant recurrence occurred in 4 patients (1 %) (Table 5). A total of 126 patients were identified who had at least 3 years' follow-up (median 45 months); of these patients, 2 (1.6 %) had locoregional recurrence alone, 1 (0.8 %) had distant recurrence alone, and 1 (0.8 %) had simultaneous local and distant recurrences. Cumulative incidence of recurrence and times to local and distant recurrence are shown in Fig. 2, with simultaneous local and distant recurrence included as both a local and a distant recurrence. None of the local recurrences occurred in the NAC skin. To date, no subsequent cancers have developed after any of the cases done in genetic mutation carriers.

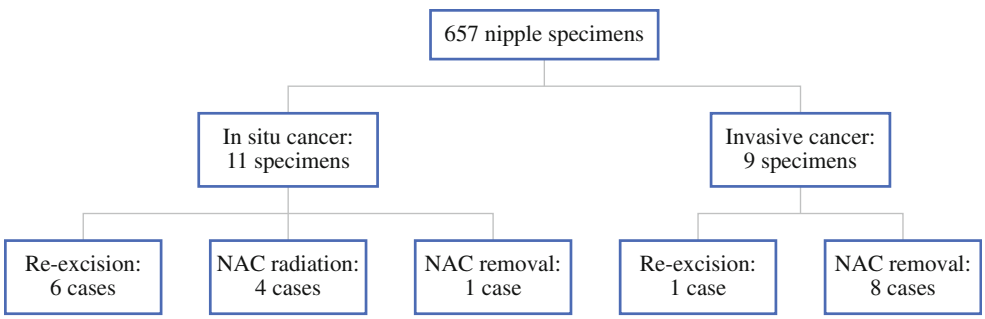

FIG. 1 Management of positive nipple involvement on pathologic analysis

TABLE 5 Oncologic outcomes in therapeutic cases

Patient group	*n*	Local recurrence only, *n* (%)	Distant recurrence only, *n* (%)	Simultaneous local and distant recurrence, *n* (%)	Any recurrence, *n* (%)	NAC skin recurrence, *n* (%)
All patients						
Total	412	4 (1)	8 (1.9)	4 (1)	16 (3.9)	0 (0)
Invasive cancer	301	2 (0.7)	8 (2.7)	3 (1)	13 (4.4)	0 (0)
In situ cancer	111	2 (1.8)	0 (0)	1 (0.9)	3 (2.7)	0 (0)
Patients with minimum 3 years' follow-up						
Total	126	2 (1.6)	1 (0.8)	1 (0.8)	4 (3.2)	0 (0)
Invasive cancer	95	1 (1.1)	1 (1.1)	1 (1.1)	3 (3.3)	0 (0)
In situ cancer	31	1 (3.2)	0 (0)	0 (0)	1 (3.2)	0 (0)

NAC nipple–areolar complex

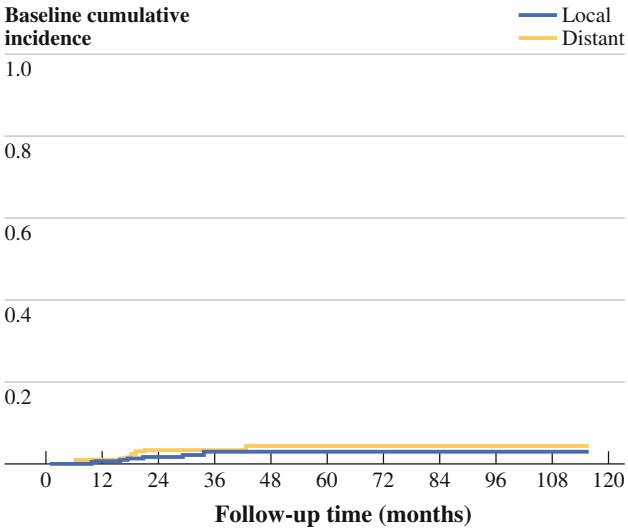

FIG. 2 Times to local and distant recurrence

DISCUSSION

This study represents the largest series in the literature reporting oncologic outcomes and surgical complication rates after total skin-sparing mastectomy and immediate reconstruction. At an overall median follow-up of 28 months, including 126 cases with minimum 3-year follow-up, locoregional recurrence rates were 2.6 % and nipple loss occurred in only 1.5 % of cases.

When our group first began performing TSSM in 2001, we evaluated all patients preoperatively with breast MRI and excluded patients with large central tumors, involvement of the skin, or tumor within 2 cm of the nipple. However, over time, we have found that we are technically able to perform the procedure and still achieve negative tumor margins even with tumors directly underneath the NAC if there is not any direct tumor involvement of the nipple itself. Further, we now perform TSSM in patients initially presenting with skin involvement who have responded well to neoadjuvant chemotherapy, though we continue to exclude patients with persistent skin involvement after systemic treatment. Although most cases reported in the literature have been performed for risk reduction or early-stage breast cancer, other centers are also now extending the use of the technique to patients with larger tumors and locally advanced disease.[9,11,12] Additionally, we had previously excluded patients who had undergone prior circumareolar incisions for breast reduction or breast augmentation procedures as a result of concerns that the skin of the NAC would not be viable after TSSM. However, we have found that preservation of the NAC skin can still be achieved in these patients without increased rates of vascular compromise to the nipple if sufficient time (at least 6 months at our institution) for wound healing is ensured.[13] Performing this procedure in women with large or very ptotic breasts can be challenging, as TSSM is best-suited for women with small-to-medium sized breasts and minimal ptosis. However, in women with moderate ptosis, we use a superior areolar/mastopexy incision for the mastectomy, which helps improves cosmesis and reconstructive outcomes by lifting the NAC and redraping the breast skin. For women who are very large-breasted or have significant ptosis, we typically encourage oncoplastic reduction mammoplasty or reduction of the skin envelope with skin-sparing mastectomy without preservation the NAC.[14] However, more recently, we have had some success reducing the skin envelope during TSSM by using reduction mammoplasty incisions with de-epithelializing of the lower pole skin and preserved blood supply to the NAC.[15]

Even with the shift towards less restrictive selection criteria, we have found low rates of tumor involvement of the nipple tissue on pathologic analysis. These rates are comparable to other large series, which report rates of 2–10 %.[1,4,9,16] Although many centers routinely perform subareolar frozen section analysis to confirm the absence of

tumor extending into the nipple, we have chosen to examine the tissue through serial sectioning at the time of final pathologic analysis given the small number of cases in which tumor within the nipple is actually discovered. If tumor is discovered within the nipple, our algorithm for further management has evolved over time. In our early experience, our approach was conservative and entailed NAC removal for specimens containing invasive or in situ cancer. However, as recurrence rates after TSSM have remained very low and we have gotten more experienced with the technique, we now manage tumor near or in the nipple skin the way we would manage positive skin margins in patients undergoing any type of mastectomy, which includes repeat excision, resection of the involved skin, or postmastectomy radiotherapy. Repeat excision is performed to ensure removal of any residual ductal tissue or residual tumor; however, all repeat excision specimens demonstrated only fibrous tissue and scar without any residual ductal tissue or cancer. Although NAC removal is typically performed if invasive cancer is found within the nipple specimen, we will attempt NAC preservation through repeat excision in patients who are highly motivated to preserve their NAC. Of the 20 nipple specimens containing tumor in this series, more than half of the cases were managed with repeat excision (and subsequent negative margins) or NAC radiation rather than complete removal of the NAC; none of these patients has developed a subsequent locoregional recurrence.

Much of the reluctance to use nipple-preserving techniques comes from concern for potentially higher rates of locoregional recurrence, echoing the concerns when skin-sparing techniques were introduced. Although follow-up data are still somewhat limited, some recent studies from centers that adopted the technique early have shown promising results. Boneti et al. reported outcomes from 281 TSSM cases with 25.3 months mean follow-up and a 4.6 % locoregional recurrence rate.[9] Jensen et al. published results from 149 cases without any locoregional recurrences developing in patients who had NAC skin preservation at mean 5-year follow-up.[2] Kim et al. reported locoregional recurrence rates of 2 % in 152 patients with mean 5-year follow-up.[12] We found similarly low rates of locoregional recurrence in our series, both for the group as a whole (with median follow-up 28 months) and for the subset of patients with at least 3 years' follow-up. Further, our patient population includes patients at significantly higher risk for local and distant recurrence than those described in many prior studies, yet our local recurrence rates have remained extremely low in the early follow-up period. Because many studies have shown that the peak of locoregional recurrences appears to be at 30 months, the low rate of local recurrence in our cohort would be expected to persist even with longer-term follow-up, particularly in the subset of patients who have already been followed for over 3 years.[17,18]

The oncologic safety of NAC preservation in young, high-risk patients undergoing risk reduction procedures, particularly genetic mutation carriers, has also been questioned. Performing TSSM in these patients rather than subcutaneous mastectomy addresses some of these concerns for oncologic safety by ensuring resection of all nipple tissue while still maintaining the appearance and projection of the NAC skin. Review of the literature in which TSSM techniques have been used for prophylactic mastectomies demonstrates good oncologic outcomes, with minimal risk of developing subsequent breast cancers, even in studies including significant numbers of genetic mutation carriers.[1,3,4,19] In our population, none of the 38 cases in patients with known *BRCA1* or *BRCA2* mutations who underwent bilateral prophylactic TSSM have developed subsequent breast cancers, though further follow-up will be important to confirm the long-term safety in this population.

In addition to the oncologic issues surrounding the technique, concern for NAC viability and potentially increased complication rates has been another major factor affecting the adoption of TSSM approaches. However, after reviewing our initial experience with TSSM and immediate reconstruction, we determined identifiable technical factors that increased postoperative complication rates and have been able to significantly reduce NAC and reconstructive complication rates through modifying our techniques.[8] To reduce NAC complications, we have found that the extent of periareolar incisions must be limited to less than one-third of the diameter of the NAC or must avoid the NAC entirely; this clinical observation of improved NAC viability with limited periareolar incisions is consistent with anatomic studies demonstrating the role of the subdermal vascular plexus in nipple blood supply after TSSM.[20] Thus, most cases since our early experience have been performed through inframammary or limited superior areolar incisions, with a subsequent reduction in NAC complications to 1.8 % in our contemporary cohort. Although comparing NAC complication rates between studies can be challenging as a result of variable reporting and definitions of NAC necrosis, most large studies report rates under 10 %, with the largest series reporting rates from 0.3 % to 2.5 %.[1,9,16] In conjunction with these studies, our results demonstrate an acceptable rate of NAC complications and support the technical feasibility of performing TSSM.

In addition to the impact of the TSSM incision used, NAC complications can also be affected by reconstructive factors. Performing only minimal immediate expansion of the thin mastectomy skin flaps and NAC skin left after TSSM is critical; currently, all of our prosthetic reconstructions are done with a two-stage expander-implant technique with minimal intraoperative expander inflation and immediate autologous reconstruction after TSSM is rarely performed. These approaches not only minimize

NAC ischemic complications, but also minimize mastectomy skin flap necrosis, which can lead to more severe complications of infection or expander-implant loss. Information regarding rates of reconstructive complications after TSSM is limited in the literature both because many studies have focused solely on NAC complications and because nearly all of the data have been collected retrospectively. However, the few studies that have included rates of expander-implant loss after TSSM have not described significantly different outcomes from those after skin-sparing mastectomy, reporting low expander-implant loss rates of 0 to 6 %.[1,3,9,16,19] Although most patients in these studies did not have advanced disease and thus did not receive postmastectomy radiotherapy, we found similarly low rates of expander-implant loss, even with the higher percentage of patients receiving postmastectomy radiotherapy, after switching to a two-stage expander-implant technique and no longer performing immediate permanent implant placement.

Reducing postoperative complications has been a major focus for our group since we began using the TSSM technique. By the time that we had performed 100 TSSM cases, we had made key improvements to our technique that significantly changed the viability of the procedure and it rapidly became the procedure of choice for our entire group. Because reducing ischemic complications to an acceptable level after our early experience, we have continued to make serial improvements to our TSSM technique using a quality improvement approach. Through meticulous, prospective collection of complications data, we have previously demonstrated that selective use of an acellular dermal matrix in expander-implant reconstruction after TSSM in patients at high-risk for surgical complications can significantly reduce reconstructive complications.[21] More recently, we have begun using complete submuscular coverage of tissue expanders in an attempt to provide similar reductions in complication rates without the added cost. These targeted interventions are designed to effect local complications without altering the oncologic safety of the procedure.

In summary, in this large, high-risk cohort, total skin-sparing mastectomy was associated with low rates of nipple involvement and loco-regional recurrence. Although overall follow-up is still early, oncologic safety was confirmed even among the subset of patients with greater than 3 years' follow-up. Rates of ischemic complications of the NAC and reconstructive complications were low and improved further once the learning curve was overcome. These results further support the oncologic safety and technical feasibility of TSSM approaches.

ACKNOWLEDGMENT The authors wish to thank Dan Moore, PhD, for his assistance with statistical analysis.

REFERENCES

1. de Alcantara Filho P, Capko D, Barry JM, Morrow M, Pusic A, Sacchini VS. Nipple-sparing mastectomy for breast cancer and risk-reducing surgery: the Memorial Sloan-Kettering Cancer Center experience. *Ann Surg Oncol.* 2011;18:3117–22.
2. Jensen JA, Orringer JS, Giuliano AE. Nipple-sparing mastectomy in 99 patients with a mean follow-up of 5 years. *Ann Surg Oncol.* 2011;18:1665–70.
3. Spear SL, Willey SC, Feldman ED, et al. Nipple-sparing mastectomy for prophylactic and therapeutic indications. *Plast Reconstr Surg.* 2011;128:1005–14.
4. Sacchini V, Pinotti JA, Barros AC, et al. Nipple-sparing mastectomy for breast cancer and risk reduction: oncologic or technical problem? *J Am Coll Surg.* 2006;203:704–14.
5. Komorowski AL, Zanini V, Regolo L, Carolei A, Wysocki WM, Costa A. Necrotic complications after nipple- and areola-sparing mastectomy. *World J Surg.* 2006;30:1410–3.
6. Margulies AG, Hochberg J, Kepple J, Henry-Tillman RS, Westbrook K, Klimber VS. Total skin-sparing mastectomy without preservation of the nipple–areola complex. *Am J Surg.* 2005;190:907–12.
7. Wijayanayagam A, Kumar AS, Foster RD, Esserman LJ. Optimizing the total skin-sparing mastectomy. *Arch Surg.* 2008;143:38–45.
8. 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.
9. Boneti C, Yuen J, Santiago C, et al. Oncologic safety of nipple skin-sparing or total skin-sparing mastectomies with immediate reconstruction. *J Am Coll Surg.* 2011;212:686–93.
10. Southern DA, Faris PD, Brant R, et al. Kaplan-Meier methods yielded misleading results in competing risk scenarios. *J Clin Epidemiol.* 2006;59:1110–4.
11. Paepke S, Schmid R, Fleckner S, et al. Subcutaneous mastectomy with conservation of the nipple–areolar skin. *Ann Surg.* 2009;250:288–92.
12. Kim HJ, Park EH, Lim WS, et al. Nipple–areola skin-sparing mastectomy with immediate transverse rectus abdominis musculocutaneous flap reconstruction is an oncologically safe procedure: a single center study. *Ann Surg.* 2010;251:493–8.
13. Vaughn CJ, Warren Peled A, Esserman LJ, Foster RD. Feasbility of performing total skin-sparing mastectomy in patients with previous periareolar incisions. Presented at: California Society of Plastic Surgeons Annual Meeting, Coronado, CA, 2012.
14. Warren Peled A, Foster RD, Esserman LJ. A comparison of oncoplastic reduction mammoplasty and mastectomy with immediate reconstruction in patients with locally advanced breast cancer. Presented at: Pacific Coast Surgical Association Annual Meeting, Napa, CA, 2012.
15. Rusby JE, Gui GPH. Nipple-sparing mastectomy in women with large or ptotic breasts. *J Plast Reconst Aesth Surg.* 2010;63:e754–5.
16. Radovanovic Z, Radovanovic D, Golubovic A, Ivkovic-Kapicl 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;99:115–8.
17. Forbes JF, Cuzick J, Buzdar A, et al. Effect of anastrozole and tamoxifen as adjuvant treatment for early-stage breast cancer: 100-month analysis of the ATAC trial. *Lancet Oncol.* 2008;9:45–53.
18. Early Breast Cancer Trialists' Collaborative Group. Effects of chemotherapy and hormonal therapy for early breast cancer on recurrence and 15-year survival: an overview of randomised trials. *Lancet.* 2005;365:1687–17.

19. Crowe JP, Patrick RJ, Yetman RJ, Djohan R. Nipple-sparing mastectomy update: one hundred forty-nine procedures and clinical outcomes. *Arch Surg.* 2008;143:1106–10.
20. Rusby JE, Brachtel EF, Michaelson JS, et al. Breast duct anatomy in the human nipple: three-dimensional patterns and clinical implications. *Breast Cancer Res Treat.* 2007;106:171–9.
21. Warren Peled A, 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.* In press.