A Process for Quantifying Aesthetic and Functional Breast Surgery: I. Quantifying Optimal Nipple Position and Vertical and Horizontal Skin Excess for Mastopexy and Breast Reduction

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Background: This article defines a comprehensive process using quantified parameters for objective decision making, operative planning, technique selection, and outcomes analysis in mastopexy and breast reduction, and defines quantified parameters for nipple position and vertical and horizontal skin excess. Future submissions will detail application of the processes for skin envelope design and address composite, three-dimensional parenchyma modification options.

Methods: Breast base width was used to define a proportional, desired nipple-to-inframammary fold distance for optimal aesthetics. Vertical and horizontal skin excess were measured, documented, and used for technique selection and skin envelope design in mastopexy and breast reduction. This method was applied in 124 consecutive mastopexy and 122 consecutive breast reduction cases. Average follow-up was 4.6 years (range, 6 to 14 years).

Results: No changes were made to the basic algorithm of the defined process during the study period. No patient required nipple repositioning. Complications included excessive lower pole restretch (4 percent), periareolar scar hypertrophy (0.8 percent), hematoma (1.2 percent), and areola shape irregularities (1.6 percent). Delayed healing at the junction of vertical and horizontal scars occurred in two of 124 reduction patients (1.6 percent), neither of whom required revision. The overall reoperation rate was 6.5 percent (16 of 246).

Conclusions: This study defines the first steps of a comprehensive process for using objectively defined parameters that surgeons can apply to skin envelope design for mastopexy and breast reduction. The method can be used in conjunction with, or in lieu of, other described methods to determine nipple position. (Plast. Reconstr. Surg. 132: 65, 2013.)

For more than five decades, surgeons have quantified individual parameters in mastopexy and breast reduction, including areola-to-inframammary fold distance,1-3 sternal notch-to-nipple distance,4 areolar diameter, and other measurements. Surgeons have defined nipple position relative to sternal notch-to-nipple dimension,4 relative to other fixed landmarks of the breast,5 or by visually identifying the apex of the breast mound intraoperatively. No defined,

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comprehensive process that bases technique selection, nipple position, skin and parenchymal modification, and outcomes assessment on quantified parameters for mastopexy and breast reduction exists in the literature. An optimal, quantified process for aesthetic and functional breast surgery requires the following:

1. Defining a decision process for clinical evaluation and operative planning.
2. Defining and quantifying parameters (objective, not subjective) and measurements that are used for decision making, operative planning, technique selection, and outcomes analysis.
3. Defining the desired dimensions of the postoperative breast by objective measurements, incorporating those measurements into operative planning to define skin envelope modification.
4. Designing parenchyma repositioning and volume modification to optimally fill the dimensions of the desired, preoperatively planned skin envelope.

This article defines a comprehensive process using quantified parameters for objective decision making, operative planning, technique selection, and outcomes analysis in mastopexy and breast reduction; and defines quantified parameters for nipple position, vertical skin excess, and horizontal skin excess. To comply with Journal space requirements, a second article will detail implementation of the processes for skin envelope design in mastopexy and reduction, and a third article will address parenchyma modification options for those procedures. This process has been applied to mastopexy and breast reduction over a 14-year period.

Nipple position on the breast and the relationship of the nipple-to-inframammary fold distance to the base width dimension of the breast is critical to optimal aesthetics.\textsuperscript{1-3,5-10} When the nipple-to-inframammary fold distance is excessively short for a specific base width, the breast appears "boxy," and when the nipple-to-inframammary fold distance is excessively long, the breast appears "bottomed-out"; however, these are subjective terms subject to wide variability. The wider the breast, the longer the nipple-to-inframammary fold distance for optimal aesthetics. The dimensions of the breast envelope and the degree of fill of the envelope determine breast shape and aesthetics, and those dimensions can be quantified.

Evidence-based medicine prioritizes objectivity over subjectivity. \textit{Subjective} terms used to describe the breast in currently published studies, including the terms "wide," "narrow," "boxy," "bottomed," "tight," "loose," and "constricted," allow different observers to interpret visual observations differently. For decades, a lack of objective descriptors and measurements in breast surgery has limited objectivity, scientific validity, and objectively defined outcomes in breast augmentation, mastopexy, and breast reduction.

This study introduces a quantified approach to planning nipple position based on relationships of the base width to the nipple-to-inframammary fold distance that have been verified in breast augmentation studies\textsuperscript{5-10} and that can be applied to mastopexy and breast reduction skin envelope design. This process can be used in conjunction with, or in lieu of, other published methods of determining nipple position.\textsuperscript{1-4,11,12} Quantifying nipple position and desired intraoperative nipple-to-inframammary fold distance enables surgeons to quantify vertical and horizontal skin excess in the breast and then use those parameters to implement more quantified and objectively documented decision processes, technique selection, and outcomes analysis.

METHODS

The Process

Figure 1 is an algorithmic representation of the process used in this study. Details of each step in the process are presented in this and pending submissions.

Defining Nipple Position

All measurements of the breast lower pole skin envelope were performed with the skin under maximal stretch, using a flexible tape measure. For defined breast width ranges, this study assigns a prospective, desired intraoperative nipple-to-inframammary fold distance from a table of simplified relationships derived from relationships established in previous breast augmentation studies\textsuperscript{5-9} modified to simplify functionality for mastopexy and breast reduction (Table 1).

In the figures that follow, camera angle and viewing perspective have been set to provide the optimal viewpoint for viewing the marking techniques, and in some views, the nipple position will not appear to be optimal on the breast mound because of point of view and distortion of the breast to position it for optimal viewing of the markings.
Quantify and Design Desired Postoperative Breast Dimensions

Define Desired Nipple Position

Measure Existing NIMF Under Maximum Stretch = NIMF Existing

Define Desired N:IMF Proportionate to Base Width NIMF Desired

Define Vertical Skin Excess VSE = NIMF Existing - NIMF Desired

Select Design for Skin Envelope Modification and Parenchyma Fill Based on Envelope Dimensions and VSE/HSE

Individualized by Surgeon

Select Technique for Mastopexy or Reduction Based on VSE

VSE Range < 3cm

VSE Range 3-4 cm

VSE Range > 4 cm

Skin Excision in Envelope Design

Periareolar

Periareolar Plus Vertical

Periareolar Plus Vertical Plus Horizontal

Mark Desired Skin Excision Pattern

Measure and Record Horizontal Skin Excess HSE from Skin Pattern or Intraoperatively

Design Parenchyma Modifications to Optimally Fill Desired Envelope Dimensions

Design Parenchyma Modifications, Removal or Repositioning

Adjust Parenchyma Volume and Position to Optimally Fill Designed Skin Envelope Dimensions

Assess Outcomes and Modify Decision Processes Based on Quantified Data

Measure NIMF and Other Desired Parameters Postoperatively

Evaluate Outcomes Based on Quantified Data

Modify Technique Selection and Design Based on Quantified Data

Fig. 1. Comprehensive process for a quantified approach to mastopexy and breast reduction. NIMF, nipple-to-inframammary fold distance; VSE, vertical skin excess; HSE, horizontal skin excess.
Table 1. Nipple-to-Inframammary Fold Distance for a Specific Base Width Range to Use for Preoperative Planning and to Set Intraoperatively

<table>
<thead>
<tr>
<th>Base Width</th>
<th>Proportionate NIMF</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.0–11.5 cm</td>
<td>7 cm</td>
</tr>
<tr>
<td>12.0–13.5 cm</td>
<td>8 cm</td>
</tr>
<tr>
<td>14–16 cm</td>
<td>9 cm</td>
</tr>
<tr>
<td>&gt;16 cm</td>
<td>10 cm</td>
</tr>
</tbody>
</table>

NIMF, nipple-to-inframammary fold distance.

The surgeon draws a meridian line of the breast from the clavicle to the 6-o’clock position of the inframammary fold. Measuring from the 6-o’clock position of the inframammary fold superiorly along the meridian line with the lower pole skin under maximal stretch, the surgeon marks a point on the meridian line at a distance equal to the nipple-to-inframammary fold distance measurement chosen for a specific base width (Fig. 2). As an alternative to the nipple-to-inframammary fold dimension settings from Figure 1, the surgeon can multiply the measured base width of the preoperative breast by 0.67 and use that measurement as a proportionate nipple-to-inframammary fold dimension up to but not exceeding 10 cm. Surgeons who prefer to distribute excess skin vertically with vertical incision techniques can nevertheless use these parameters for marking and to objectively quantify vertical and horizontal skin excesses that are being redistributed.

Lifting the breast to put the lower pole skin under maximal stretch and bring the previous mark to the apex of the breast lower pole on the meridian, the surgeon holds a skin marker immediately anterior to the mark (Fig. 3). The surgeon then releases the upper breast to allow the breast to fall inferiorly, and then moves the skin marker directly posterior to touch the skin along the superior meridian line to define the desired nipple position (Fig. 4).

To confirm the desired nipple position, the surgeon measures the same desired nipple-to-inframammary fold distance (selected based on breast base width) from the nipple directly inferiorly along the meridian line with the skin maximally stretched, and places a mark at that point (Fig. 5). With one hand fixing that marked point inferiorly to the 6-o’clock position of the inframammary fold, the surgeon lifts the upper breast until the nipple is in ideal position on the apex of the breast mound (Fig. 6). The hand holding the upper breast and nipple-areola in position remains immovable, and the surgeon releases the other hand from the inframammary fold, grasps
a skin marker, and stabilizes the marker immediately anterior to the nipple (Fig. 7). The surgeon then releases the upper breast, the breast slides inferiorly, and the surgeon moves the skin marker a few millimeters directly posteriorly to contact the meridian line and make a mark (Fig. 8).

This second mark should coincide exactly or closely with the initial mark the surgeon made to define the optimal nipple position. The surgeon reconciles any differences by precise repeated measurements, always focusing on the more inferior of the two marks. In addition, the surgeon can compare the nipple to a position determined by any other method, including the method of locating the nipple at the level of the projected inframammary fold introduced by Arič⁶¹ and popularized by Pitanguy.¹²

**Quantifying Vertical Skin Excess**

Objectively defining desired nipple position and nipple-to-inframammary fold distance enables surgeons to objectively define the vertical skin excess in the breast, and then use vertical skin excess as a key decision parameter when selecting one of the various skin envelope modification alternatives in mastopexy and reduction. To define vertical skin excess, the surgeon first marks the most superior point of the areola 2 cm superior to the nipple position on the breast meridian. From that point, the surgeon measures inferiorly along the breast meridian a distance equal to the diameter of the areola plus the dimension of the projected, desired nipple-to-inframammary fold distance defined previously, and marks a point on the meridian that defines the areola-to-lower
Fig. 9. To define vertical skin excess (VSE), the surgeon marks the most superior point of the areola (SA) [0.5 x areola diameter (AD)] superiorly above the nipple (N), and then measures inferiorly along the meridian a distance equal to the areola diameter plus the proportionate desired nipple-to-inframammary fold distance \( \text{NIMF}_{\text{desired}} \) selected from Figure 1, and marks that point (red line). The distance from that point to the inframammary fold, measured under maximal stretch, is the vertical skin excess.

...pole distance required for optimal aesthetics. The distance from that point to the existing inframammary fold quantifies vertical skin excess (Fig. 9). Vertical skin excess is defined by the following formula: \( \text{vertical skin excess} = \text{existing nipple-to-inframammary fold dimension} - \text{most superior point of the areola to desired nipple-to-inframammary fold distance} \).

**Quantifying Horizontal Skin Excess**

After selecting a desired method for mastopexy or breast reduction based on quantified skin excess parameters or on personal technique preferences, the surgeon marks the skin excision pattern for the procedure selected. (See Video, Supplemental Digital Content 1, which documents quantified methods for determining optimal nipple position during preoperative marking, [http://links.lww.com/PRS/A748](http://links.lww.com/PRS/A748).) The surgeon then measures the distance between the widest points of skin excision to define horizontal skin excess.

The relationship of horizontal skin excess to vertical skin excess varies considerably with each of the following: breast base width, skin stretch variations in specific areas of the breast, parenchymal amount and distribution (that the surgeon leaves), and many other factors. Vertical skin excess also varies with these factors, but this comprehensive system prioritizes vertical skin excess and uses vertical skin excess to determine horizontal skin excess when using excisional techniques. When surgeons choose to redistribute rather than excise vertical skin excess (i.e., in periareolar or vertical incision techniques), horizontal skin excess is determined by measurement of only the widest point between the lateralmost incision points for skin excision. Additional details of how these measurements are applied to mastopexy and reduction are beyond the scope of this article and will be included in pending submissions that define the details of how the measurements are used for operative planning and postoperative assessment for a range of techniques in mastopexy and reduction. This method was used to define desired nipple position and skin excess in 124 consecutive mastopexy and 122 consecutive breast reduction cases from 1994 to 2012.

Patients were considered candidates for mastopexy whenever their measured preoperative nipple-to-inframammary fold distance exceeded 9.5 cm. Periareolar mastopexy was limited to patients with a vertical skin excess of 3 cm or less; periareolar plus vertical mastopexy or reduction was limited to patients with 3 to 4 cm of vertical skin excess, and vertical plus transverse envelope reduction (inverted T, with varying length horizontal component) was limited to patients with vertical skin excess greater than 4 cm. The method for determining nipple position remained constant over the period of this study.

**RESULTS**

This report is limited to defining the overall process, quantifying nipple positioning, and defining methods to quantify vertical and horizontal skin excess. A component analysis and surgical planning approach, selecting and designing skin envelope and parenchymal modifications independently, was used for all cases and will be reported separately with quantified postoperative...
outcomes data to comply with Journal space requirements.

No patient in this series required or requested repositioning of the nipple following the primary procedure. The average follow-up was 4.6 years (range, 6 to 14 years).

The average vertical skin excess was 4.6 cm (range, 2.2 to 8.1 cm) for mastopexy patients and 7.4 cm (range, 2.7 to 13.2 cm) for reduction patients. The average horizontal skin excess for mastopexy patients was 3.4 cm (range, 2.0 to 6.6 cm).

Complications included excessive lower pole restretch (defined as >20 percent of the desired nipple-to-inframammary fold distance that was set intraoperatively) in four of 124 mastopexy patients (3.2 percent) (with no simultaneous or staged augmentation) and six of 122 reduction patients (4.9 percent). Six revisions were performed in these patients. Hematoma occurred in one of 124 mastopexy patients (0.8 percent) and in two of 124 reduction patients (1.6 percent).

Four patients who had periareolar mastopexy with permanent pursestring sutures requested removal of the suture because of palpability. Two of 246 patients (0.8 percent) required revision of periareolar scars because of scar hypertrophy, and four of 246 patients (1.6 percent) required areolar circumference revision for asymmetric areolar stretch or shape. All areola shape revisions occurred in patients in whom the areola skin excision was incorporated into a Wise pattern or vertical skin excision pattern instead of defining skin excision intraoperatively after closure of the vertical incision. Delayed healing at the junction of vertical and horizontal scars occurred in two of 124 reduction patients (1.6 percent), neither of which required revision. The overall reoperation rate was 6.5 percent (16 of 246).

**DISCUSSION**

This study introduces an objective, quantified process for planning nipple position and quantifying skin excess in the breast based on relationships of the base width to the nipple-to-inframammary fold distance that enables surgeons to use quantified parameters in decision making, surgical planning, and outcomes assessments. This study does not advocate any specific technique for mastopexy or reduction, compare this process with any other method, or address any comparisons between mastopexy or reduction techniques. Other methods, such as positioning the nipple at the level of the projected inframammary fold have been proved effective, but no currently published study quantifies nipple position on the breast mound based on relationships of the base width to the nipple-to-inframammary fold distance, and quantifies vertical and horizontal skin excess.

In his classic 1956 article, Wise suggested that for optimal aesthetics, the nipple should be located at "the most prominent portion of the breast," or the most projecting apex of the breast mound. By deriving his skin excision pattern from a Cordelia of Hollywood surgical bra, he also tangentially defined a concept similar to that presented in this article, that areola-to-inframammary fold distance (and therefore nipple-to-inframammary fold distance) should increase as the cup size (and therefore base width) increases, a concept later reiterated by Lassus. Strombeck used a sternal notch-to-nipple distance of 22 cm for nipple positioning (22 to 24 cm in ptotic breasts), and Lassus used 2 cm below a midhumeral point projected onto the breast. Ari used the projected inframammary fold as the optimal level for the nipple, acknowledged by Pitanguy, who later popularized that concept (Pitanguy's point).

Many surgeons locate the nipple on the apex intraoperatively by visually defining the apex of the breast mound. This subjective, visual method, without objective preoperative and intraoperative measurements of the nipple-to-inframammary fold distance (which almost uniformly changes with postoperative stretch and wound healing forces), makes objective evaluation of postoperative results challenging. A common example is the "bottomed-out" breast. Is the subjective appearance postoperatively caused by (1) the surgeon choosing an excessively "high" nipple position, (2) the surgeon leaving an excessively "long" nipple-to-inframammary fold distance intraoperatively relative to base width, (3) unplanned and excessive stretch of the nipple-to-inframammary fold distance skin postoperatively, or (4) a combination of these factors? Simple preoperative, intraoperative, and sequential postoperative nipple-to-inframammary fold distance measurements applied with the process in this article can objectively answer these questions.

During this study, the vertical skin excess ranges in Table 1 that were used to select a skin excision pattern evolved to minimize revisions and limit patients having to tolerate gathered skin closures. Surgeons can choose to distribute greater amounts of vertical skin excess into periareolar and vertical closures, or to excise vertical skin excess with the tradeoff of a variable length horizontal scar in the inframammary fold.
on their experience and the desires of their individual patient populations. Regardless of the technique a surgeon selects, this process allows the surgeon to quantify parameters that can be objectively assessed postoperatively over time.

Although caliper and tape measure measurements are technologically simple, they have been shown to be extremely reliable and cost effective, and enable surgeons to describe breasts, plan operations, and evaluate results using quantified measurements in addition to visual, subjective parameters. All measurement methods have limitations. The accuracy of measurements and volumetric estimation is likely to improve as affordable technology advances are validated.

It is critically important that the surgeon make all measurements of the breast lower pole envelope (nipple-to-inframammary fold distance) with the skin under maximal stretch using a flexible tape measure to most accurately simulate the stretch that results from tightening the skin envelope. Consistency of measurement data requires this methodology and, currently, no imaging technology can accurately and consistently measure lower pole dimensions with the skin under maximum stretch. The following principles derived from breast augmentation

1. Optimal nipple position on the breast mound can be defined by a specific, quantified measurement from the only fixed landmark of the breast, the inframammary fold.
2. The optimal nipple-to-inframammary fold distance that defines optimal nipple position varies with, and is proportionate to, the base width of the breast.
3. Optimal nipple position is located on or near the meridian line of the breast.
4. The relationships of the base width to the nipple-to-inframammary fold distance (measurements) that have produced optimal aesthetic results in breast augmentation can be applied directly to determining ideal nipple position in mastopexy and breast reduction.

Optimal nipple position on the breast relates most accurately to landmarks on the breast, not landmarks on any other part of the body, because breast position varies on the torso. Stated another way, optimal aesthetics are defined by the position of the nipple on the breast mound, not by the relationship of the nipple to any landmark off the breast. For example, if a patient's breasts are located lower than average on her torso, an "ideal" sternal notch-to-nipple measurement to define optimal nipple position would place the nipple excessively superiorly on the breast mound.

The measurements included in Table 1 were purposefully simplified at the outset of the study to test the basic validity of the method before applying it to large numbers of cases. Alternatively, surgeons can multiply preoperative base width by 0.67 to derive a proportionate nipple-to-inframammary fold distance.

The consistency and predictability of early and long-term results using the simplified base width ranges and desired nipple-to-inframammary fold distance measurements in Figure 1, and the desire to introduce as few variables as possible, resulted in no modifications to the initial parameters in Table 1 over the duration of this study. Surgeons can certainly interpolate to 0.5-cm increments from these measurements for even greater accuracy if they desire, and can revise relationships of the base width to the desired nipple-to-inframammary fold distance if their data prompt those changes.

The principles and techniques used in this study were shared with other surgeons more than a decade ago, and their application of the principles and processes are pending. Other surgeons have recently published quantified methods that enable much more objective evaluation of outcomes in vertical scar reduction mammoplasty.

Every technique for selecting optimal nipple position has limitations, and postoperatively, many wound healing and tissue variables affect nipple position and tissue stretch—variables that neither surgeon nor patient can predictably control. Before any breast surgical procedure, every patient should be informed that no woman has two nipples that are in the same position, and that despite the most precise measurements and surgical techniques, precisely symmetric nipple positions are not achievable because of the uncontrollable variables involved. Once informed, the patient should document acceptance of these facts in informed consent documents preoperatively.

**CONCLUSIONS**

First, by defining a quantified method for nipple positioning and defining vertical and horizontal skin excess, this study defines the first steps of a comprehensive process for using objectively defined parameters that surgeons can apply to
skin envelope design for mastopexy and breast reduction. Second, quantifying desired nipple-to-inframammary fold distance enables surgeons to objectively quantify vertical and horizontal skin excess, and then choose techniques based on those parameters. Third, the method described in this study can be used in conjunction with, or in lieu of, other described methods of determining nipple position in mastopexy and breast reduction. Finally, quantified decision methods, operative planning, and preoperative marking produce objective data that, compared with subjectively derived parameters, enable surgeons to more objectively and scientifically plan and evaluate different mastopexy and breast reduction techniques and more effectively address the requirements of evidence-based medicine.

REFERENCES