Breast Surgery

Preliminary Report

Nipple Reconstruction After Autologous or Expander Breast Reconstruction: A Multimodal and 3-Dimensional Analysis

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Mathias Tremp, MD; Pietro G. di Summa, MD, PhD; Dominique Schaakxs, MD, PhD; Carlo M. Oranges, MD; Reto Wettstein, MD; and Daniel F. Kalbermatten, MD, PhD

Abstract

Background: Little is known about the influence of the underlying tissue as donor for nipple-areola complex (NAC) reconstruction. Also, there is a complete lack of knowledge about the fate of nipple volume.

Objectives: The goal of this retrospective, single-institution study was to analyze a case series after nipple reconstruction using a multimodal evaluation including 3-dimensional (3D) laser scanner analyses.

Methods: Unilateral mastectomy patients after either expander-based or autologous breast reconstruction using the skate flap were included. NAC caliper measurement of nipple and areola size was performed. 3D laser scanner analysis (Minolta Vivid 900) was used to calculate nipple volume, measurement of nipple, and areolar projection and diameter. Sensitivity was evaluated using the Semmes Weinstein test and patient satisfaction by a visual analog scale (VAS 1-10).

Results: A total of 10 patients were included in the expander group and 12 patients were included in the flap group. After a median follow-up period of 32 months in the expander group and 34 months in the flap group, non-contact 3D laser surface scanning revealed a difference in projection of 55 to 60% compared to the contralateral side. The contraction in all 3 dimensions led to a dramatic difference in nipple volume with 12 ± 8% (flap reconstructions) and 12 ± 7% (expander reconstructions). Sensitivity of the areola showed better values after expander-based reconstruction. Despite the significant discrepancy in nipple volume and projection as well as areolar diameter, overall patient satisfaction was acceptable (VAS 4.1 ± 3.5).

Conclusions: Volume assessment revealed a massive asymmetry to the intact nipple but not between expander and flap reconstructions. Although asymmetry of the areola and nipple remains, patient satisfaction is acceptable.

Level of Evidence: 4

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Dr Tremp is a Plastic Surgeon and Attending, Dr Oranges is a Plastic Surgeon and PhD candidate, Dr Wettstein is a Plastic Surgeon and Consultant, and Prof Kalbermatten is a Plastic Surgeon and Medical Director at the Department of Plastic, Reconstructive, Aesthetic and Hand Surgery, University Hospital Basel, Basel, Switzerland. Dr di Summa is a Plastic Surgeon and Attending, and Dr Schaakxs is a Resident, Division of Plastic, Reconstructive, and Aesthetic Surgery, CHUV, University Hospital of Lausanne, Lausanne, Switzerland.

Corresponding Author:
Dr Daniel F. Kalbermatten, Medical Director, Plastic, Reconstructive, Aesthetic and Hand Surgery, University Hospital Basel, Spitalstrasse 21, 4031 Basel, Switzerland.
E-mail: daniel.kalbermatten@usb.ch

Most patients consider nipple reconstruction as an important aesthetic factor of their corporal identity in the reconstructive process.[1-3] Despite of a multitude of techniques of nipple reconstruction described,[4] none seems to be entirely satisfactory and loss of projection with time remains a major issue.[5,6] Depending on the reconstructive technique used, decreases in projection between 50 and 70% have been described, with most of the shrinking occurring within the first year after reconstruction.[7,8] Interestingly, the influence of the underlying tissue, that is, the technique of breast reconstruction on involution of the neo-nipple has not been investigated. Nipple projection is relatively easy to measure. However, current methods only describe 1 dimension and do not reflect the overall nipple involution that occurs in all 3 dimensions. Therefore, not only the projection of the reconstructed nipple is an issue, but the final volume of the reconstructed nipple is also a parameter that has not yet been analyzed. With laser surface-scanning technology, the volume of the nipple can be objectified and the current lack of information on the 3D fate of the reconstructed nipple can be overcome.

Therefore, we analyzed a series of patients who underwent either expander or autologous transverse rectus abdominis myocutaneous (TRAM)/deep inferior epigastric perforator (DIEP) flap reconstruction after unilateral non-skin sparing mastectomy using a multimodal evaluation including the feasibility of 3D laser scanner analyses.

METHODS

In this retrospective study, all patients who underwent delayed nipple reconstruction with a skate flap in cases of unilateral reconstruction with a TRAM/DIEP flap (with a skin paddle) or an expander after unilateral non-skin sparing mastectomy and without contralateral nipple surgery between January 2004 to September 2006 were included. The type of breast reconstruction was decided after a multidisciplinary breast reconstruction board, kept on a weekly basis at the Lausanne University Hospital. General guidelines included implant reconstruction in patients not undergoing radiotherapy after mastectomy. Patient preferences were also considered, but free flap reconstruction was proposed only to non-smoker patients. Patients suffering from postoperative complications, for example, infection, wound dehiscence, and nipple necrosis, were excluded (one in each group). Informed written consent was obtained from all patients before outcome measurement, which was performed once in the outpatient clinic after a minimal follow-up of 18 months after nipple reconstruction. During this study, the guidelines of the Declaration of Helsinki were followed accordingly.

Surgical Technique

The nipple was reconstructed with a skate flap in all cases with a dimension of 10 mm × 40 mm.[4] Resorbable sutures were removed after 2 weeks and nipple non-resorbable sutures at 3 weeks when the protective dressing was removed.

The protective foam dressing (Mepilex Safetac, Mölnlycke Health Care, Schlieren, Switzerland) was shaped with a hole in the middle to allow protection of the reconstructed nipples without compression from the top. Mepilex foam was removed from reconstructed nipples at 3 weeks together with removal of Prolene sutures.

To minimize bias, two experienced attending surgeons performed the nipple reconstructions or supervised a resident by always using the same technique. Areola reconstruction was performed by tattooing by a paramedical professional.

Follow-Up Evaluation

Nipple volume, projection, and diameter were assessed with a laser surface scanner. The scanning method has been described elsewhere in detail.[9-12] Non-contact 3D laser surface scanning was performed with a portable device (Minolta Vivid 900 3D Digitizer, Konica Minolta Inc., Chiyoda-ku, Tokyo, Japan). The scanning process lasts less than 1 second. To guarantee correct orientation of the scans (Figure 1) for analysis, both breasts were considered to perform initial registration. For further fine alignment of the scan datasets, the breast scans were separated. Since the shape of each single breast was unique and defined as such, the registration was correctly oriented. The nipple axis was determined on the frontal view by visually controlled approximation. The nipple area was defined using surface orientation inspection of each single triangle and was calculated on behalf of the surface orientation of the neighbored triangles (curvature inspection, Geomagic Inc., Research Triangle Park, Raleigh, NC). Having defined this region, the nipple volume was deleted and filled with respect to the curvature of the neighbored surface triangles to have volume datasets. Determination of the nipple volume was then performed using Boolean operation (Magics, Materialise, Leuven, Belgium). The volume of the flat nipple scan dataset was subtracted from the volume of the nipple scan dataset. The gained results could be displayed in info boxes.

The non-reconstructed nipple was considered 100% for both projection and volume. The differences between the reconstructed and intact sides are indicated in percentage. In addition, nipple projection was classified as identical if the difference was <1 mm, as moderately asymmetric (1-3 mm discrepancy), or asymmetric if >3 mm difference was measured. As a "one size fits all" flap was used in all cases, some degree of asymmetry was expected. All scan data were analyzed by an engineer not involved in patient

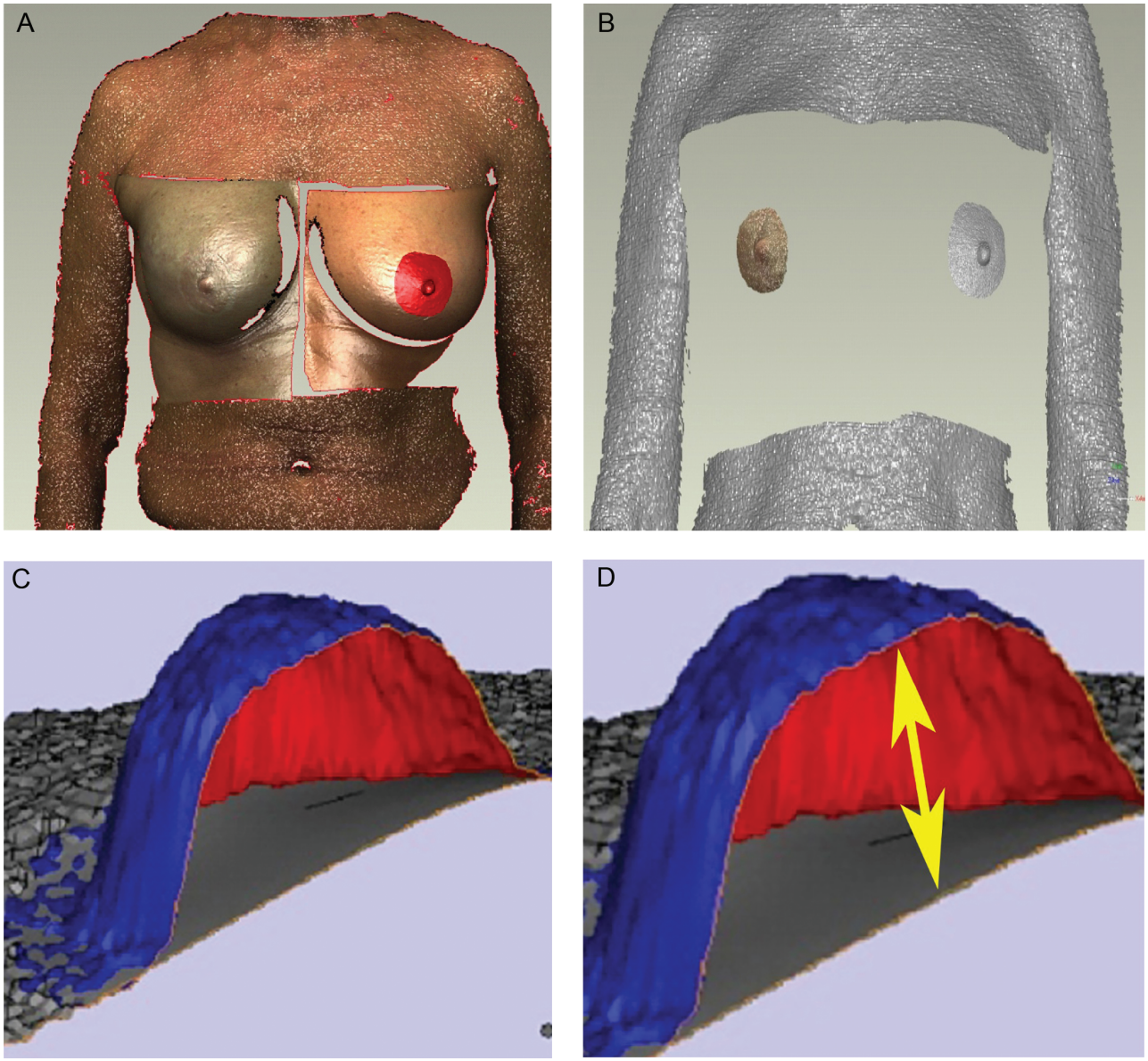

Figure 1. Example of a typical laser surface scanning image of the torso of a 62-year-old woman 3 years after expander-based breast reconstruction on the right side (A, B) and the representation of the nipple (C, D), virtually transected in the middle to permit measurement of projection (6.561 mm, yellow arrow).

care and who was unaware of the technique of breast reconstruction used. In addition to scanning, nipple projection was also assessed with a caliper by a surgeon not involved in the breast and nipple reconstruction. Both laser scanning data and caliper measurements were recorded using the metric system (mm). Areolar size was classified as symmetric, intermediate, and asymmetric if discrepancy was less than 25% or more than 75%. Temperature (cold and hot) was assessed and rated as none, some or clear sensitivity for touch, and as some or none for temperature. Sensory testing was undertaken using Semmes Weinstein monofilaments as previously described.[13,14] The patient was measured in an upright position at room temperature and the monofilaments were applied perpendicular to the breast skin. On each breast, 3 measurements were taken at the nipple while the patient had their eyes closed. The tactile threshold was defined as the minimal bending force of the thinnest filament sensed by the patient, and one affirmative response indicated a positive result. The finest measurement of sensation was defined to a pressure of 0.07 grams and was considered the normal value for a non-operated breast. Color match was evaluated from digital photographs taken at follow-up and judged as either match or mismatch. A 31-year-old female plastic surgery

resident (3 years post-graduate), who was not involved in the reconstruction and independent from the study, measured all parameters. Finally, during the in-office final follow-up visit, patients were asked to score their satisfaction with the NAC reconstruction with a VAS scale (ranging from 0 if not satisfied to 10 if completely satisfied).

Statistical Analysis

Data are presented as mean ± standard deviations (SD), or median and range where appropriate. The chi-square test and Fisher's exact test were used where appropriate to determine statistical differences between the 2 groups; $P < .05$ was determined to be significant. The correlation was calculated at a 5% level using the Pearson correlation coefficient.

RESULTS

A total of 22 patients were enrolled. Of those, 10 underwent expander reconstruction and 12 had flap reconstruction. There was no significant difference ($P = .36$) between the age in the expander group (median, 43 years; range, 30-59 years) and the age in the flap group (median, 44 years; range, 29-64 years). Median follow-up was 32 months (range, 18-68 months) vs 34 months (range, 18-57 months) in the expander and flap groups, respectively. Overall, we observed 2 complications (8.7%) during the follow-up period: one erythema and infection of the nipple and one moderate hematoma. Both complications healed uneventfully with conservative management.

The projection of the reconstructed nipples was significantly less than the contralateral non-operated nipple approximately 2½ years after the reconstruction. Laser scanning analysis of the non-operated nipple of all patients resulted in an average diameter as measured at the mid-distance from the bottom to the top of the nipple of 11.8 ± 2.0 mm, a projection of 6.0 ± 2.2 mm, and a volume of 324 ± 180 mm^3. There was a significant difference in projection between the operated and non-operated side in the flap reconstruction group (3.4 ± 1.6 mm vs 5.7 ± 1.5 mm, $P = .003$) and in the expander group (3.0 ± 1.2 mm vs 6.2 ± 2.8 mm, $P = .004$). Furthermore, there was a significant difference in diameter and volume between the operated and non-operated side in the flap reconstruction group (12.2 ± 1.3 mm and 14.6 ± 1.6 mm, $P = .001$, 42 ± 41 mm,[3] and 329 ± 155 mm^3, $P = .000012$, respectively). In the expander group, there was no significant difference in diameter but a significant difference in volume between the operated and non-operated side (11 ± 2 mm vs 13 ± 2 mm, $P = .07$, 37 ± 37 mm^3 and 320 ± 209 mm^3, $P = .0004$, respectively). A good correlation ($r = 0.88$, $P < .0001$) between manual caliper measurements and laser scanning was observed (Figure 2). Interestingly, 26.1% of patients (n = 6) in both groups had a side difference of projection of less than 1 mm (Figure 3).

This significant difference in projection of approximately 55 to 60% was moderate when compared to difference in nipple volume. Nipple volume on the healthy side was 329 ± 155 mm^3 and 320 ± 209 mm^3 in the flap reconstruction group and expander group, respectively. Neo-nipple volumes were drastically smaller at follow-up and virtually identical in the two groups with 12 ± 8% and 12 ± 7% of the contralateral side, or 42 ± 41 mm^3 and 37 ± 37 mm^3 in the flap, respectively expander groups. No significant differences could be detected between the two groups ($P = .99$, chi-square test) (Figure 3). In terms of nipple projection and volume, no difference was identified by subgroup analysis of the surgeons performing the operations.

The size of the areola was considered equal in 45% of the cases with only slight differences between the 2 groups. However, 25% in the flap group were considered asymmetric compared to 5% in the expander group. Nipple sensitivity to touch was slightly better ($P = .7$, chi-square test) in expander reconstructions with only 20% of patients having no sensitivity in contrast to 50% in flap reconstructions (Figure 4). Temperature sensation was only minimal in both groups and not significant ($P = 1.0000$, Fisher's exact test; Figure 5). Color match was evaluated positively in 50% of flap reconstructions and in 70% of expander reconstructions.

Patient self-assessment of their satisfaction with the NAC reconstruction revealed that expander reconstructed patients are slightly more satisfied ($P = .08$, chi-square test) with the result than patients after autologous breast reconstruction (Figure 6). No attempt was made to evaluate the reasons for increased satisfaction, such as sensitivity, volume and projection of the nipple, and lack of donor site. Representative clinical cases are available as Figures 7-10.

DISCUSSION

The important asymmetry in projection after NAC reconstruction has previously been reported[6-8,15] and is confirmed by the present study. It is well known that the most

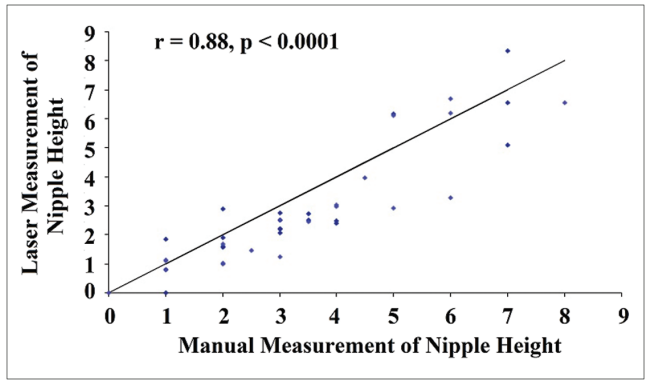

Figure 2. Correlation between nipple projection as measured with the caliper, respectively, as assessed with laser surface scanning.

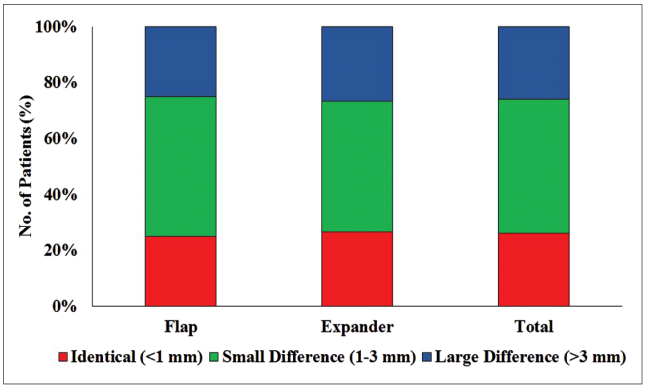

Figure 3. Differences in nipple projection between the reconstructed and healthy side demonstrated as percentage of patients who present with a large difference (blue bars), small difference (green bars), or virtually identical (red bars) nipple height.

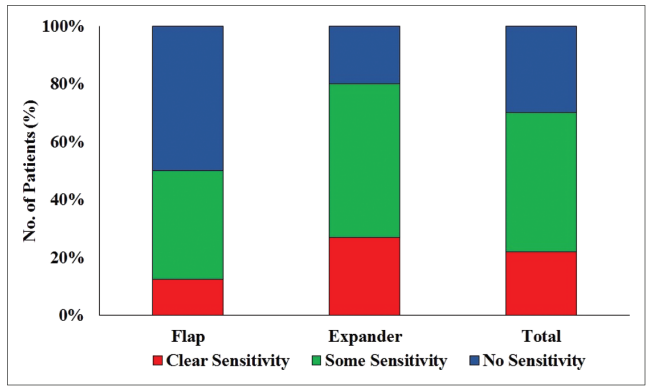

Figure 4. There was a trend toward improved sensitivity to touch in the expander group. Interestingly, 38% of patients indicated some sensitivity after flap reconstruction.

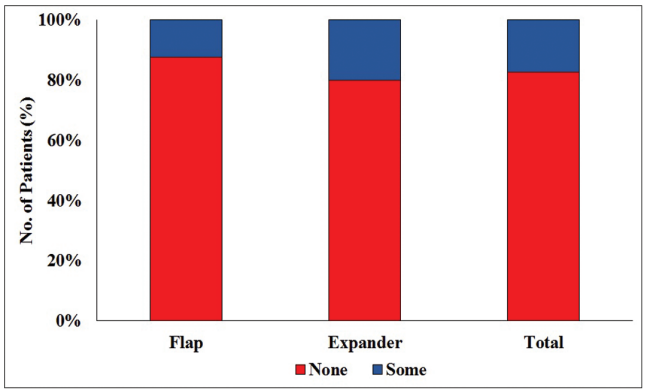

Figure 5. In contrast to pressure sensitivity, cold sensitivity was absent in 83% of patients, in both expander and autologous reconstructions.

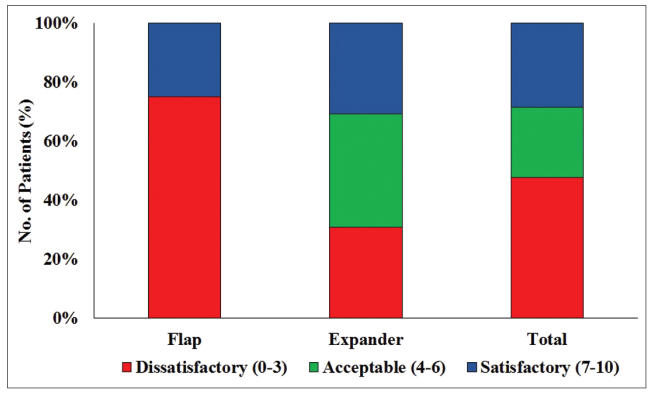

Figure 6. Satisfaction was higher in patients after nipple reconstruction in the expander group than in the flap group, indicating that patients who are willing to undergo flap reconstruction have higher expectations with regard to the outcome.

common point of dissatisfaction after NAC reconstruction is the lack of long-term nipple projection, followed in descending order by color mismatch, unattractive shape, size and texture and, finally, nipple malposition.[5,16]

Assessing symmetry is challenging, and 3D laser scanning techniques have been shown to offer a quantitative metric in breast surgery.[17,18] The laser scanning technology used in this study added a new dimension to the evaluation of successful nipple reconstruction. To the best of our knowledge, laser scanning technology for evaluation after nipple reconstruction including volumetric analysis has not yet been reported in the literature. It is a simple, objective, fast, inexpensive, and reliable tool in preoperative planning, intraoperative assessment, and postoperative follow-up to potentially assess symmetry and volumetric dynamics over time. Whereas an asymmetry of approximately 50% in projection was observed, the 3D neo-nipple involution was even more dramatic, with almost 90%. This underscores the importance for 3D analysis in the evaluation of novel techniques of nipple reconstruction, as well as the need for improved techniques of nipple reconstruction. On the other hand, it was surprising to find a relatively positive evaluation on patient satisfaction. The assessment of patient satisfaction, however, was only rudimentary and it has been shown that nipple reconstruction positively influenced overall patient satisfaction.[1,2,19]

Whereas some improvement in nipple projection has been described with alternative techniques of nipple reconstruction, mostly relying on the addition cartilage grafts or synthetic materials, these methods do not seem to have gained widespread acceptance and only small series have been reported on so far.[20-27]

A shortcoming of this retrospective study is that the initially created volume and projection of the nipple are not known and it may be the case that nipples reconstructed via expander reconstruction were smaller from the beginning when compared to nipples reconstructed from abdominal flap tissue for the above-mentioned reason. If this were to

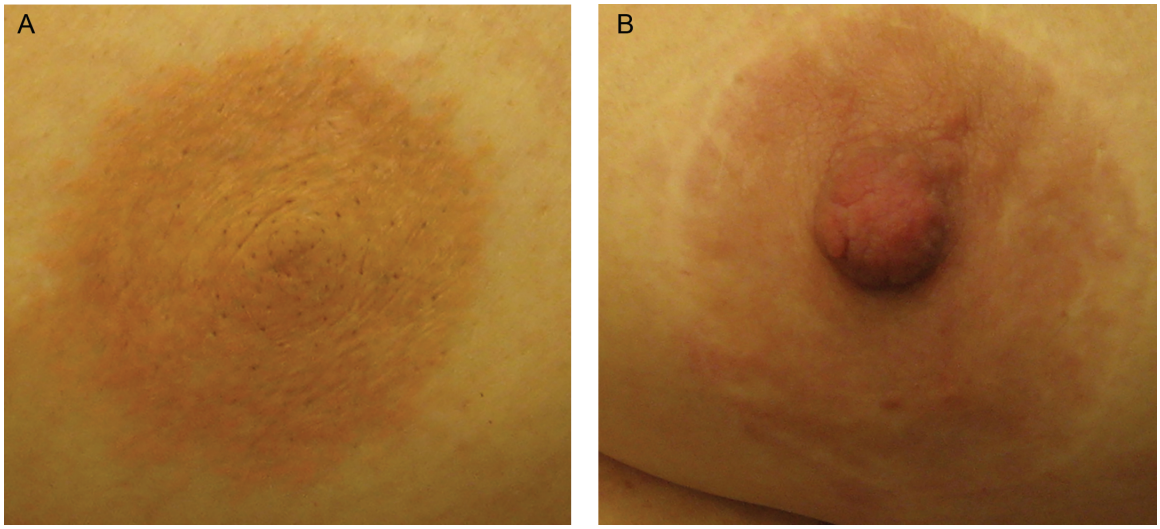

Figure 7. (A) A 64-year-old woman after flap-based breast reconstruction and 34 months after NAC reconstruction and (B) the healthy, contralateral nipple-areola complex.

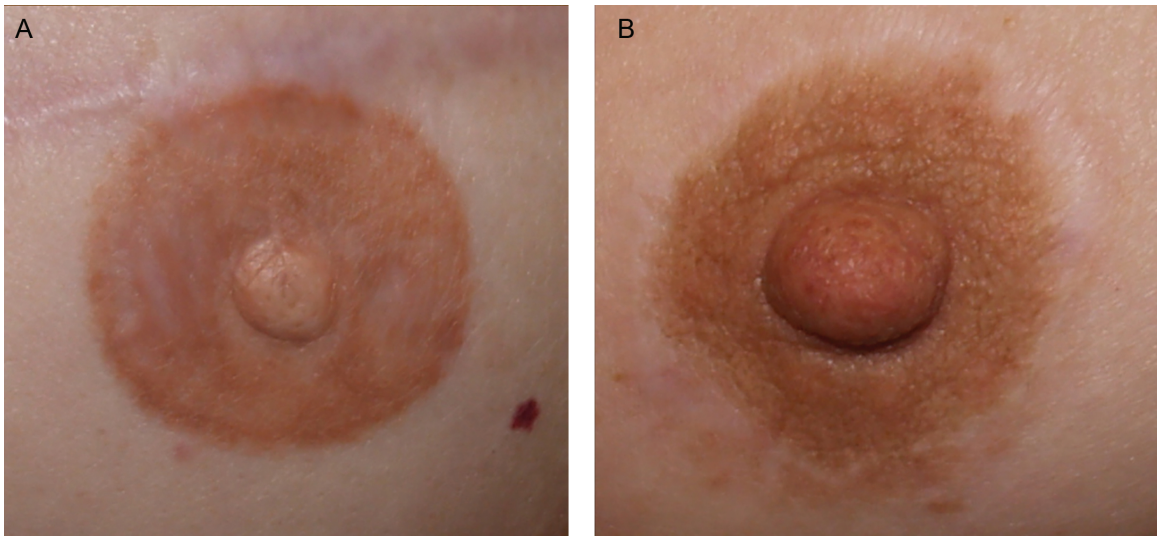

Figure 8. (A) A 53-year-old woman after expander-based breast reconstruction and 32 months after NAC reconstruction and (B) the healthy, contralateral nipple-areola complex.

hold true, it would imply that expander reconstructions show a less severe contraction with time. However, the final result is still unacceptable, with only about 10% of the contralateral volume. Overall, it cannot be stated whether flap vs expander reconstructions are genuinely different. A further limitation is that this is a single-institution study. Therefore, more prospective, large-scale, multicenter studies are needed to further validate our findings.

It is well known and documented that asymmetry of breast dimensions exist in non-operated[28-30] and operated women.[31] Rohrich et al showed that NAC asymmetry was present in 24% (nipple/areola size) and 53% (nipple position) of the women after bilateral breast augmentation,[31] whereas Westreich showed that only 52% of non-operated, "aesthetically perfect" breasts had symmetrically round areolas.[31]

Furthermore, because of the retrospective nature of the study, there are no immediate postoperative assessments of either the operated or non-operated nipple on which to base subsequent progress. Conclusions on how the reconstructed nipple has contracted are based on the assumption that good symmetry between both sides was achieved immediately postoperatively. As we have no data to support this assumption, this is a drawback of our study.

A potential solution to the massive difference in volume observed is the creation of a nipple that is bigger than the original was to compensate for the expected involution.[5]

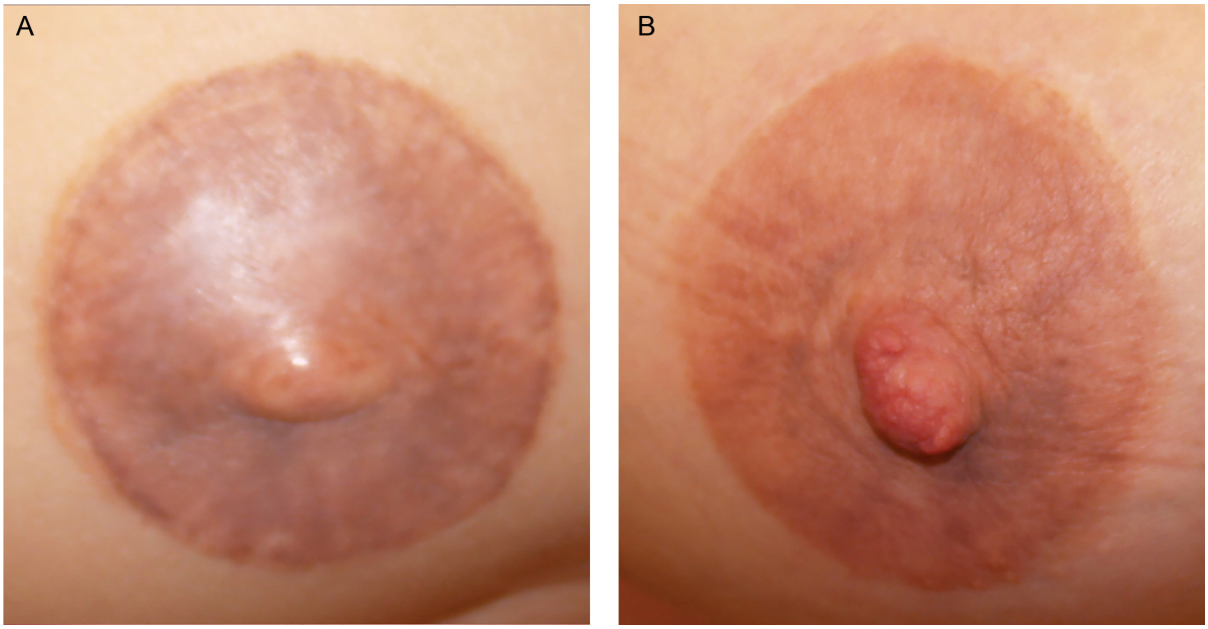

Figure 9. (A) A 44-year-old woman after flap-based breast reconstruction and 34 months after NAC reconstruction and (B) the healthy, contralateral nipple-areola complex.

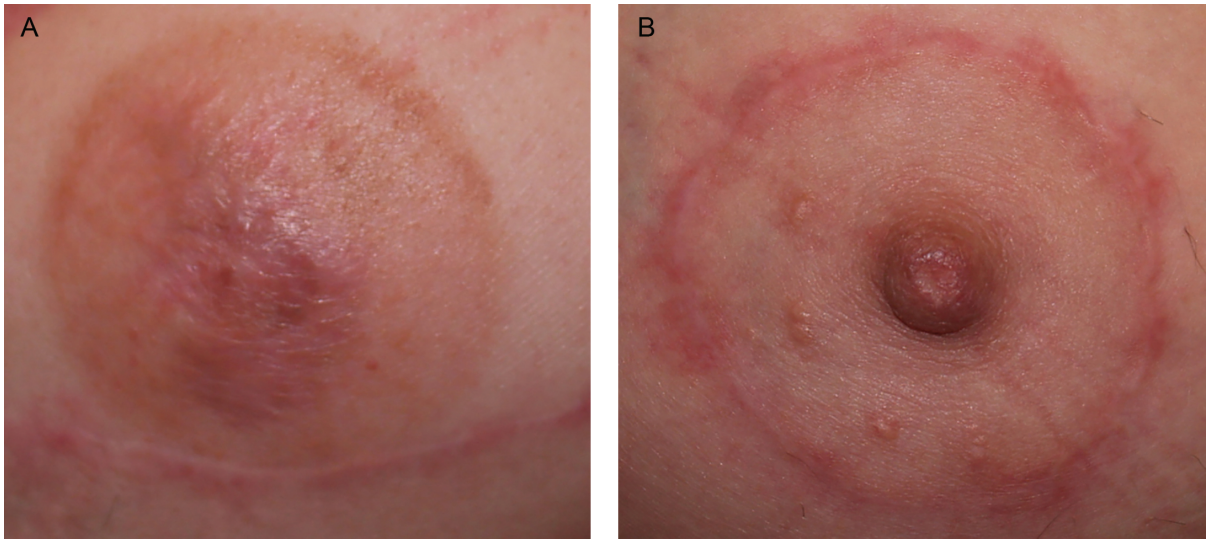

Figure 10. (A) A 40-year-old woman after expander-based breast reconstruction and 32 months after NAC reconstruction and (B) the healthy, contralateral nipple-areola complex.

However, the amount of tissue available is limited and should be confined to the diameter of the future areola. In addition, an increase in nipple volume is associated with a decrease in breast mound projection.[32]

Since the expanded tissue is sensate, it is not surprising to find better sensitivity in expander reconstructions. However, this difference was limited, which can be explained by spontaneous re-innervation of flaps.[33,34] Sensitivity was restricted to touch and almost absent to temperature stimulation. Whereas sensate reconstruction of the nipple has been described,[35] evaluation of nipple sensitivity is not a parameter usually investigated upon after breast reconstruction.[7] In a recent prospective study by Brown, sensory changes following subfascial breast augmentation were evaluated in 162 consecutive women using a Semmes Weinstein monofilament test before surgery, 2, 6, and 12 weeks postoperatively.[14] In this study, 4% of NAC failed to return to preoperative levels of sensitivity by 12 weeks after surgery. Breast augmentation in this series produced calculated volume changes by an implant

of between 12.1% and 102.7%.[14] The authors argue that using Semmes Weinstein fibers might be limited, as the touch is either felt or not, limiting the sensory change to a range rather than an absolute measure.[14] Furthermore, Dellon reported that other devices such as the pressure-specified sensory device (PSSD) might be superior.[36] Nevertheless, our choices of assessment tools (Semmes Weinstein monofilaments, temperature sensitivity, and color[37]) are in line with the literature.[37-39] Importantly, the Semmes Weinstein fibers allow progress of a patient to be charted in a simple manner, which is cheap and readily available. Furthermore, it permits comparison with studies that were using the same methodology.[14] Hamdi et al evaluated the sensitivity of the NAC in 20 patients undergoing breast reduction, using the Semmes Weinstein monofilaments, temperature sensitivity with hot (40°C) and cold (4°C) metal probes, and vibratory thresholds. At 3 months postoperatively, pressure and vibration threshold were quite similar to preoperative values of both the areola and nipple. Kargül showed that the best results of color match were achieved with grafting from the contralateral areola, followed by areola tattoo and skin grafts from the groin.[37]

Lastly, it has been shown that our method of measuring satisfaction has a good validity and reliability and can be used in clinical trials due to the ease of administration and interpretation.[40]

It may be that differences in dermal organization and in the perfusion pattern of expanded skin vs flap tissue can explain part of the differences observed in color match. Levites et al suggested that epidermal cells take up pigment, but then slough off over a period of weeks, leading to an exfoliative loss of pigment.[41] Furthermore, it has been observed that macrophages take up pigment and remove it from the tattoo site.[42] Prior to undertaking tattooing of a cutaneous free flap, it is most important to ensure that sufficient time has passed such that the skin is well perfused and able to heal.[43] However, a complete match is rarely possible due to changes in the surrounding skin with perfusion and sun exposure.[43] In practice, tattoo colors may be selected that compensate for the predictable changes that will occur.[41] Furthermore, El-Ali et al recommend that tattoos begin one-third darker than the physiologic contralateral nipple color.[44]

CONCLUSION

Three-dimensional volume analysis is an important endpoint in the evaluation of nipple reconstruction. With the classical skate flap reconstruction, a dramatic asymmetry of approximately 90% compared to the intact nipple could be objectified, regardless of the technique of breast reconstruction used. The results suggest that the method of reconstruction after non-skin sparing mastectomy does not influence the final nipple volume with the classic technique of nipple reconstruction. Further refinements in nipple reconstruction are needed to maintain projection and volume. Volume measurement should also be included since it reflects the 3D changes of the nipple and not only the projection.

Disclosures

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