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ORIGINAL ARTICLE

Defining Pseudoptosis (Bottoming Out) 3 Years After Short-Scar Medial Pedicle Breast Reduction

Michelle Quan · Ahmed Fadl · Kevin Small · Oren Tepper · Naveen Kumar · Mihye Choi · Nolan Karp

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Abstract
Background Pseudoptosis (bottoming out) is a well-observed phenomenon occurring after all types of breast reduction surgery. The authors' team previously reported the use of three-dimensional (3D) imaging to demonstrate that significant morphologic changes occur in the breast during the first year after short-scar medial pedicle breast reduction. This study extended this evaluation to postoperative year 3.
Methods Patients undergoing short-scar medial pedicle breast reduction had 3D photographs taken using the Canfield Vectra 3-pod system or the Konica Minolta V910 during postoperative follow-up visits at 1 month, 1 year, 2 years, and 3 years. Patients were assessed for pseudoptosis and breast morphologic changes using the 3D-based measurements.
Results During the 3 year period, 10 patients completed the study. The total breast volume decreased significantly during the first postoperative year by 20.6% ($P < 0.05$). No change in volume occurred during postoperative years 2 and 3 ($P > 0.05$). Pseudoptosis was documented in the first postoperative year by a 6% migration of breast tissue from the upper pole to the lower pole of the breast ($P < 0.05$), without significant change noted during the next 2 postoperative years ($P > 0.05$). This redistribution of the breast parenchyma correlated with a decrease in breast anteroposterior projection of 10.6 mm ($P < 0.05$) during the same period, with an insignificant change during postoperative years 2 and 3. During the first postoperative year, 3D comparative analysis recorded a 4.4-mm difference in the 3D topography ($P < 0.05$) and no further changes thereafter. The angle of breast projection showed a significant decrease of 17% ($P < 0.05$) in the first postoperative year and no change in subsequent years.
Conclusion Three-dimensional photography is a useful tool enabling the plastic surgeon to monitor the postoperative changes in breast morphology objectively. This study provides quantifiable data demonstrating that pseudoptosis and tissue redistribution are limited to the initial postoperative year for patients undergoing short-scar medial pedicle breast reduction. The kinetic change in the breasts during postoperative years 2 and 3 appears to be minimal. Studies comparing the changes in morphology over time with different techniques of breast reduction are underway.

Keywords Breast morphology · Breast parenchyma · Breast reduction surgery · Pseudoptosis · Short-scar medial pedicle breast reduction

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M. Quan · A. Fadl · K. Small · O. Tepper · N. Kumar · M. Choi · N. Karp (✉)
Tisch Hospital, NYU Medical Center, New York, NY, USA
e-mail: Nolan.karp@nyumc.org

M. Quan · A. Fadl · K. Small · O. Tepper · N. Kumar · M. Choi · N. Karp
New York University School of Medicine, 305 East 47th Street, Suite 1A, New York, NY 10017, USA

Strombeck [1] defines macromastia as breasts that lead a woman to a surgical solution. Despite the physical, emotional, and psychological benefits of breast reduction, the goal of surgery should be to attain aesthetically pleasing breasts with minimal scarring [2–4]. Although this surgical procedure results in high satisfaction [5–9], issues of pseudoptosis (bottoming out) remain an inevitable long-term consequence of breast reduction surgery.

Various surgical approaches have been suggested to minimize the occurrence of pseudoptosis. However, no objective way exists to compare the results [10–13]. Unfortunately, most data on pseudoptosis have been derived from two-dimensional (2D) surface measurements and thus overlook the three-dimensional (3D) geometric structure of breasts.

Over the past few years, our team has detailed the utility of 3D imaging for quantifying changes in breast morphology [14]. We have specifically documented chronological changes in breast topography after short-scar medial pedicle breast reduction. In the first year after short-scar medial pedicle breast reduction, we objectively quantified the occurrence of pseudoptosis according to certain 3D parameters and vector measurements including changes in volumetric distribution, surface topography, and breast projection [14, 15].

The following report of our study investigates the progression of bottoming out to 3 postoperative years. Additionally, three new breast parameters that monitor the changes of the breast after medial pedicle breast reduction are introduced: the angle of the intermammary sulcus (breast cleavage), the angle of the inframammary fold (IMF), and the angle of breast projection.

Methods

Patient Enrollment and 3D Photographs

Patients undergoing breast reduction with a short-scar medial pedicle technique between August 2005 and November 2009 were offered enrollment in the study. Informed consent was obtained in accordance with the guidelines set forth by the New York University Medical Center Institutional Review Board.

Short-scar medial pedicle breast reduction was performed as previously described by the senior authors (NK, MC) [16]. Three-dimensional breast scans were obtained preoperatively, then during the early postoperative period (35–140 days), at 1 year (300–450 days), at 2 years (600–850 days), and at 3 years (1,000–1,300 days). Additionally, 3D photographs were captured with either a noncontact laser scanner (Konica Minolta-V910, Ramsey, NJ) [14–18], from 2005 to 2007, or the Canfield Vectra 3D system (Scientific Inc., Fairfield, NJ) from 2008 to 2010. All the images were analyzed with Geomagic Studio and Qualify v11 software (Research Traingle Park, NC).

Breast Volume Analysis

As previously described, all pre- and postoperative breast images were aligned to a reference *x, y,* and *z* coordinate axis, and total breast volume was computed for each breast. Concurrently, to determine the breast volume above and below an *xz* plane (*c* plane) [15] relative to the chest wall, a transverse plane was generated though the lateral borders of the IMF of the preoperative image. This fixed *c* plane was subsequently applied to all the previously aligned postoperative breast scans.

Vector Measurements

The maximum anteroposterior distance of the breast relative to the chest wall was determined for each 3D image. The maximum projection was the perpendicular distance from the chest wall to the nipple. Other vector measurements included the vector internipple distance and the vector sternal notch-to-nipple distance.

3D Color Mapping

Postoperative scans (early image of the reference object and 1-, 2-, and 3-year postoperative images of the test object) were used to generate topographic color maps for 3D comparison. The maximum and minimum distance deviations were +25 and −40 mm, respectively. Color scales were divided into 40 segments. Geomagic software generated an asymmetry score that indicated the average deviation of the breasts between the postoperative images.

Angle Measurements

The angle of breast projection, the angle at the intermammary sulcus (breast cleavage), and the angle at the IMF were determined for all images. The angle of breast projection denoted the angle of intersection of the superior pole of the breast and the chest wall (Fig. 1a). The angle at the intermammary sulcus denoted the intersection of a line tangential to the superior medial aspect of the right breast and a line tangential to the superior medial aspect of the left breast converging at the midline of the patient at the sternal notch (Fig. 1b). The angle at the IMF denoted the angle of convergence at the chest wall of a line tangential to the inferior pole of the breast and intersecting the nipple (Fig. 1c).

Statistical Analyses

All data are presented as the mean ± standard error of the mean. A paired *t*-test was used to compare early, 1-year, 2-year, and 3-year postoperative values. Statistical significance was denoted by a *P* value less than 0.05.

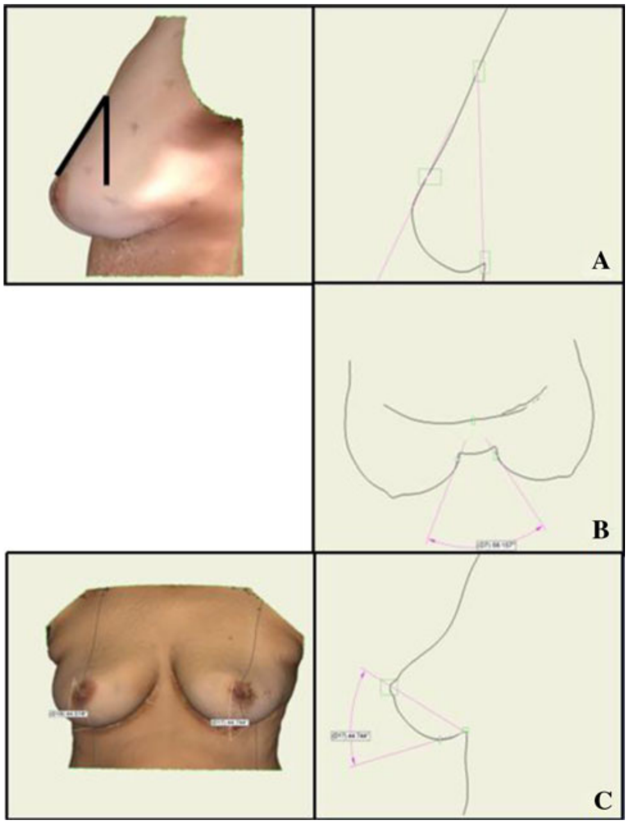

Fig. 1 **a** The angle of breast projection was identified as the angle between the superior pole of the breast and the chest wall. **b** The angle at the intermammary sulcus denotes the intersection of a line tangential to the superior medial aspect of the right breast and a line tangential to the superior medial aspect of the left breast converging at the midline of the patient at the sternal notch. **c** The inframammary fold (IMF) angle is defined as the angle between the nipple and the inferior pole of the breast, with the vertex of the angle placed at the IMF fold

Results

Patient Demographics

The average age of our patient group was 38 ± 12 years. The average weight of tissue excised per breast was 412.2 ± 189.9 g.

Long-Term Volumetric Changes and Redistribution

Total breast volume decreased significantly from the early postoperative period (605.8 ± 232.5 cm^3) to the 1-year postoperative period (481.0 ± 151.4 cm^3) ($P < 0.05$), reflecting a 20.6% reduction over the first postoperative year. However, no significant change occurred during postoperative year 2 (507.9 ± 219.2 cm^3; $P = 0.98$) or postoperative year 3 (518.7 ± 211.1 cm^3; $P = 0.81$) (Fig. 2).

To evaluate the potential redistribution of breast tissue, breast volume was calculated above and below the *c* plane through the lateral IMF. There was a significant migration of breast parenchyma from the superior pole of the breast during the first postoperative year (76% above the fold initially after surgery to 70% at 1 year postoperatively; $P < 0.05$). In comparison, redistribution of breast tissue did not occur in the following years. The tissue above the fold postoperatively was 67% at 2 years ($P = 0.61$) and 69% at 3 years ($P = 0.74$) (Fig. 3).

Long-Term Vector Analysis

The average breast projection from the chest wall to the nipple (AP distance) significantly changed from the early postoperative scan (62.4 ± 13.4 mm) to the 1-year postoperative scan (51.8 ± 13.2 mm) ($P < 0.05$). The anteroposterior distance did not vary significantly during postoperative year 2 (50.4 ± 15.4 mm; $P = 0.69$) or postoperative year 3 (53.3 ± 14.3 mm; $P = 0.46$) (Fig. 4). Additional vector measurements showed no significant differences. The surface internipple distance was 246.7 ± 18.8 mm in the early postoperative period, 234 ± 33.1 mm at 1 year, 234.6 ± 21.7 mm at 2 years, and 249.8 ± 16.6 mm at 3 years ($P > 0.05$). The sternal notch-to-nipple distance remained unchanged, measuring 218.42 ± 18.0 mm at the early time point, 205.7 ± 23.5 at 1 year, 216.4 ± 20.4 mm at 2 years, and 221.1 ± 20.6 mm at 3 years ($P > 0.05$).

Long-Term 3D Comparison

Three-dimensional comparison generated a topographic color map representing the average distance deviations (asymmetry score quantified in millimeters) between early and late postoperative images. The comparative asymmetry scores were 4.41 ± 3.75 mm at 1 year, 0.51 ± 0.90 mm at 2 years, and 0.37 ± 0.90 mm at 3 years (Fig. 5).

Angle Measurements

The breast projection angle became more acute from the early postoperative period (36.9° ± 9.7°) to the 1-year postoperative period (30.7° ± 8.6) ($P < 0.05$). The angle of breast projection was preserved in the following postoperative scans: 30.9° ± 8.5° at 2 years and 30.4° ± 8.2° at 3 years ($P > 0.05$) (Fig. 6). The cleavage angle (or intermammary sulcus) did not change significantly during all 3 postoperative years ($P > 0.05$): 44.7° ± 18.7° at the early scan, 45.2° ± 17.2° at 1 year, 46.8° ± 20.7° at 2 years, and 42.5° ± 20.6° at 3 years (Fig. 7). The IMF angle became more obtuse from the early postoperative scan (36.7° ± 10.5) to the 1-year postoperative scan (43.3° ± 8.8°), ($P < 0.05$), but remained unchanged at the

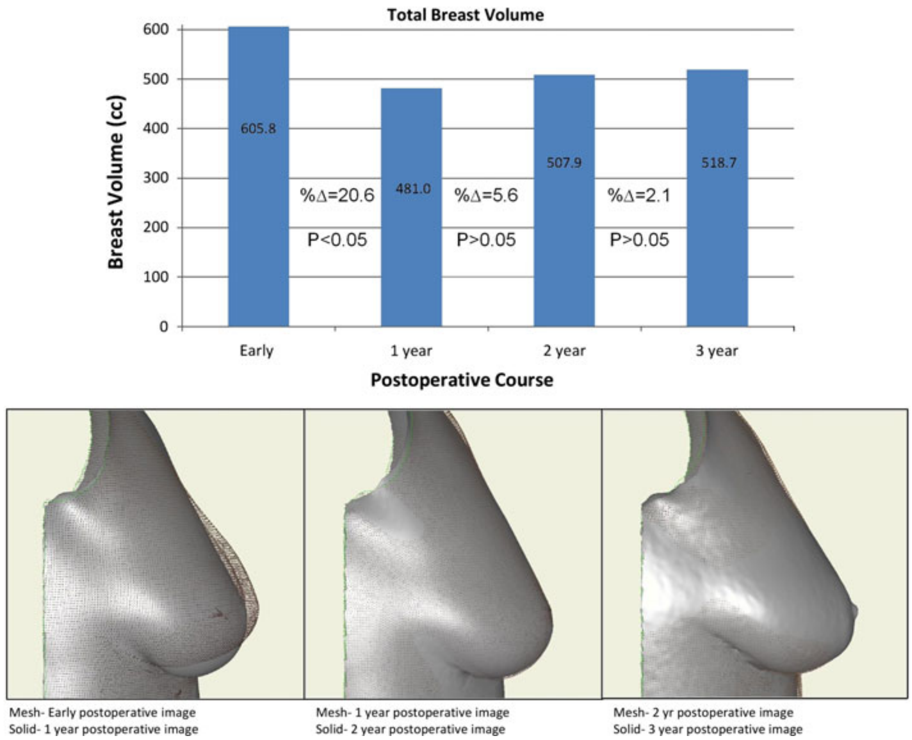

Fig. 2 Three-dimensional breast volumes were calculated for all the patients at all pre- and postoperative time points. The average breast volume from the early postoperative period to the 1-year postoperative period decreased by 20% ($P < 0.05$) and stabilized in postoperative years 2 and 3

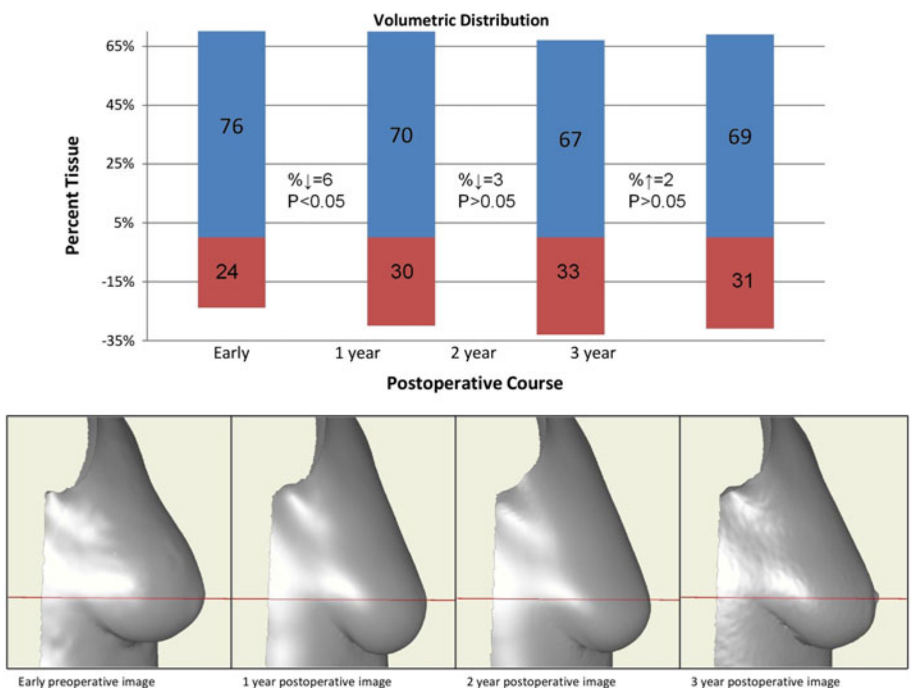

Fig. 3 A horizontal plane is generated that intersects the lateral border of the inframammary fold (IMF) to divide the breast into upper and lower poles. This plane was applied to all the postoperative images of all the patients in the study. The graph shows a significant change in volumetric distribution of 6% in the superior pole of the breast from the early postoperative period to the first postoperative year, which then stabilizes in postoperative years 2 and 3

2-year (44.5° ± 9.6°) and 3-year (43.2° ± 10.3°) follow-up assessments ($P > 0.05$) (Fig. 8).

Discussion

This study outlined the utility of 3D technology for documenting how breasts change after breast reduction surgery. Our group implemented 3D scanning to measure objectively and understand postoperative breast edema, pseudoptosis, and stabilization of breast morphologic changes over time.

We previously reported data comparing postoperative images 3 months and 1 year after short-scar medial pedicle reduction mammaplasty. In that study, we provided the first report on bottoming out in quantitative 3D terms. We noted pseudoptosis with significant redistribution of breast volume

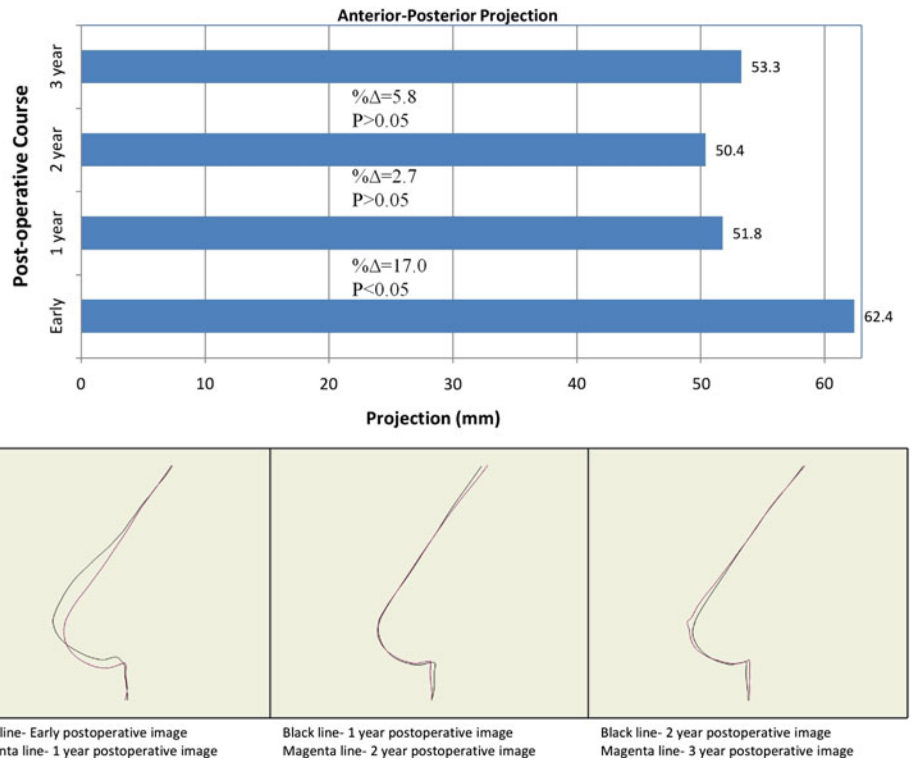

Fig. 4 The sagittal cross-section demonstrates the projection of breast tissue at the anterior most point of the nipple to the posterior most point of the chest wall. The table 2 notes that the anteroposterior projection decreases significantly by 17% over the postoperative course from the early period to the 1-year postoperative period ($P < 0.05$) and then stabilizes in postoperative years 2 and 3

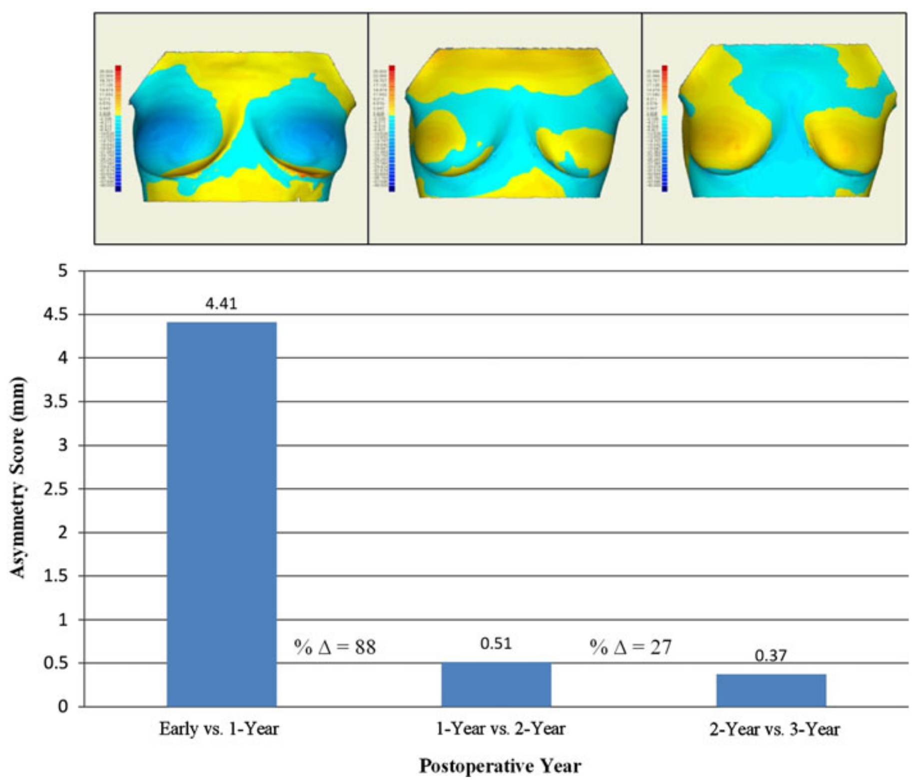

Fig. 5 A three-dimensional (3D) comparison was created by superimposing the reference image over the test image. A 3D topographic map then was generated to represent a multipoint vector sum analysis of the test points that deviated from the reference points. Darker blue correlates with negative deviations, and red correlates with positive deviations. The average asymmetry score between the postoperative early and 1-year scans, 1- and 2 year scans, and 2- and 3-year scans was 4.41 ± 3.75 mm, 0.51 ± 0.90 mm, and 0.37 ± 0.90 mm, respectively

toward the inferior pole (6.5%), a significant decrease in total breast volume (13.6%), a significant decrease in anteroposterior projection (6.2 mm), and an asymmetry score of 4.41 mm [15].

The current study continues to follow the changes in breast morphology 3 years after breast reduction surgery. Interestingly, this study confirms our previous 1-year study and shows no further change in breast

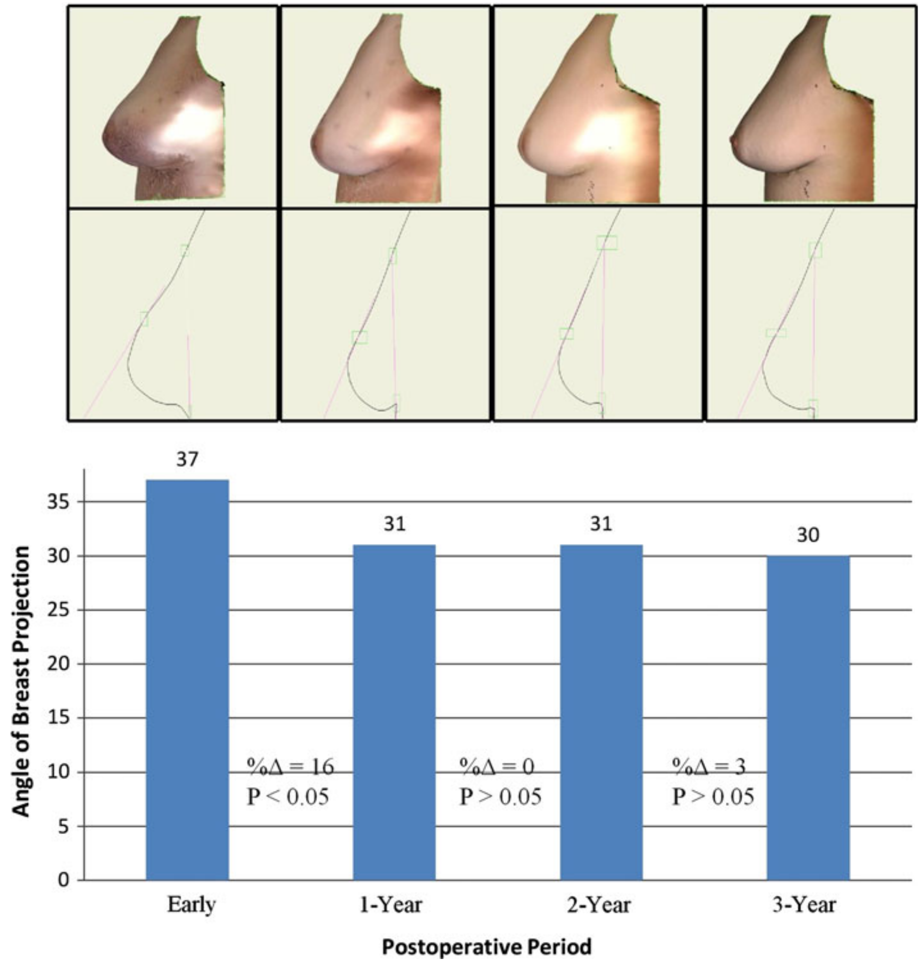

Fig. 6 The angle of breast projection was measured for all time points. The table demonstrates a significant decrease in the angle from the early period (36.9° ± 9.7°) to the first postoperative year (30.7° ± 8.6°) ($P < 0.05$) and then stabilizes in the latter years

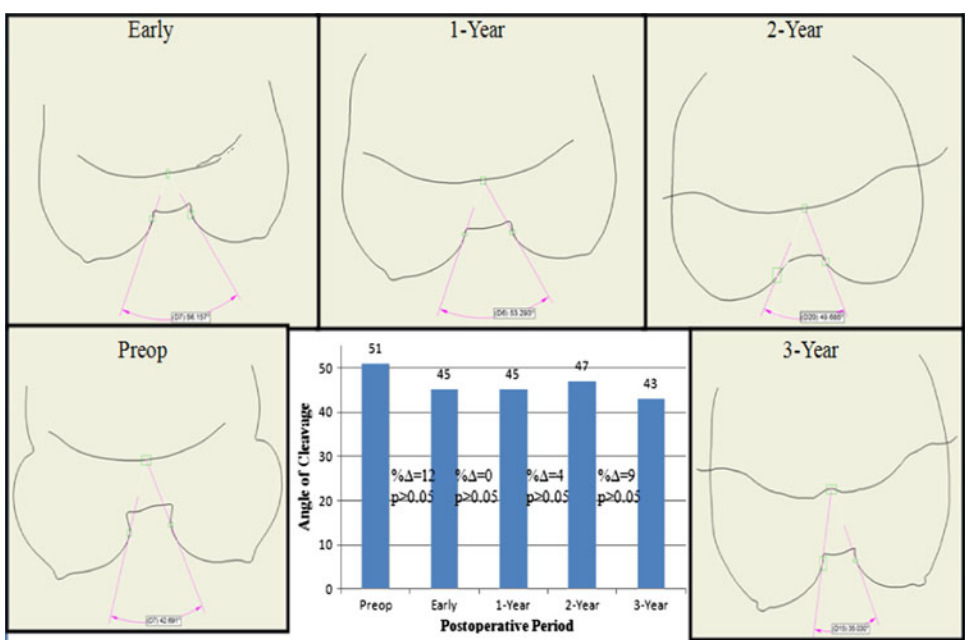

Fig. 7 The angle of cleavage was observed to be stable at all postoperative visits ($P > 0.05$)

morphology during subsequent years. We document pseudoptosis to be strictly an event isolated to the first year after surgery. Notably, to our knowledge, no other studies have objectively monitored the changes in pseudoptosis paralleling the length of time in this examination.

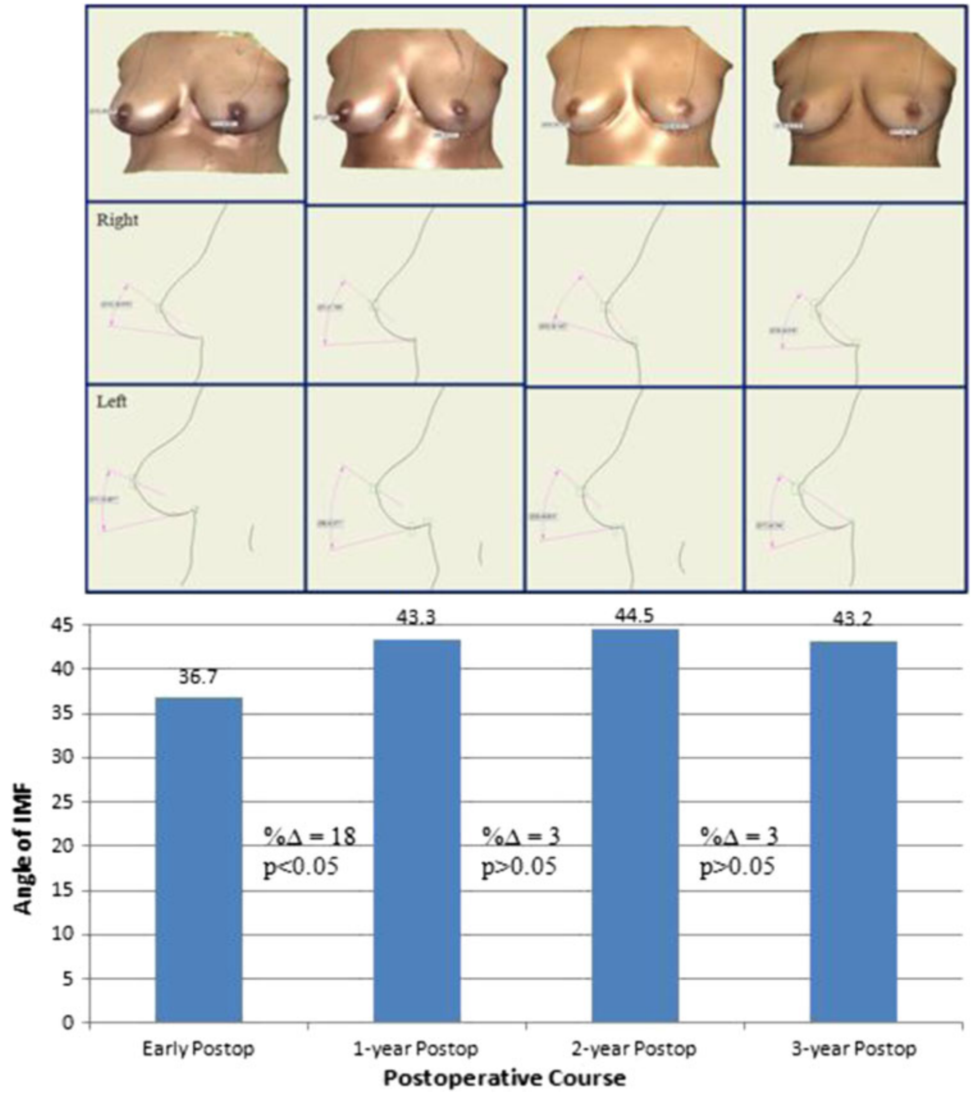

Fig. 8 The angle of the inframammary fold (IMF) was calculated to have decreased from the early period (36.7° ± 10.5°) to the 1-year postoperative scan (43.3° ± 8.8°) ($P < 0.05$) and then to have maintained stability in the 2- and 3-year postoperative scans

This study introduces new 3D breast measurements yet to be described: angle of breast projection, IMF angle, and cleavage. During the early to 1-year postoperative period, the angle of breast projection becomes significantly more acute, and the IMF angle becomes significantly more obtuse, supporting our previous findings that tissue is redistributed from the superior pole to the inferior pole of the breast. These angle measurements are stable in postoperative years 2 and 3, thus confirming that pseudoptosis is limited to postoperative year 1. Interestingly, the angle of cleavage does not change significantly at any postoperative time point. This finding correlates with the theory and development of the medial pedicle technique. The rotation and securing of the medial pedicle to the superior medial skin envelope during the surgery preserves the intermammary cleft, suggesting that redistribution of breast tissue (pseudoptosis) postoperatively may be limited to the lateral aspect of the breasts.

This study also provided a novel method for studying breast change. The term “cleavage” (intermammary sulcus or cleft) refers to the cleft between a woman’s breasts overlying the sternum. From Lejour to Hall-Findlay, plastic surgeons have modified the pedicle and incision technique to preserve superior pole fullness and thus breast cleavage after breast reduction surgery. Even clothing manufacturers (i.e., Victoria’s Secret) have modified marketing strategies to accentuate the décolletage (cleavage) of the woman to enhance her sexual attractiveness and optimize sales. No data currently exist on the ideal angle of cleavage. However, 3D imaging provides the method for assessing this anatomic landmark and monitoring its transformation postoperatively.

A potential limitation of this study was the transition of our initial screening equipment, from the Konica Minolta Vivid 910 Non Contact 3D Laser Digitizer to the Canfield Imaging System. As previously documented, the Konica

Minolta required the research analyst to maneuver the camera to 10 unique positions to capture the complete 3D topography of the breast [18]. This manipulation of patient and camera increased the time required for data acquisition and furthermore introduced an inherent variability into our data analysis. The Canfield Imaging System includes three camera pods: two pods anteroinferolateral to the breasts and one pod superior to the breasts. The pod placement allows the research analyst to capture a complete 3D surface model of the breast in a single snapshot, thus removing any variability associated with changes in patient position or breathing patterns.

An internal study of 10 patients (20 breasts) detected no statistical difference in volumetric analysis between the Konica Minolta and the Canfield Imaging System using Geomagic analytical software. Thus, the transition to the Canfield Imaging System during this 3-year study period introduced minimal variability into the screening protocol.

Our current study suggests that the application of 3D breast analysis to postoperative images may become an invaluable adjunct to preoperative surgical planning. This novel analytical tool is a major departure from conventional approaches in which surface measurements, physicians' subjective visual estimates, and patients' qualitative evaluations [19] guide perioperative decision making.

Over the years, subjective assessments and 2D measurements have guided the evolution of surgical techniques to minimize complications, reduce surgical scar, retain nipple sensation, and maintain long-term breast shape and contour. Until our current investigations, however, plastic surgeons lacked an objective analytical tool that could evaluate improvement in the shape and contour of breasts relative to their surgical technique. With the advent of 3D technologies, we currently have the ability to compare the rate of pseudoptosis associated with pedicle selection, skin incision, and suture selection. Studies are similarly underway applying these parameters to other surgical techniques.

Conclusion

This study provides quantifiable evidence that pseudoptosis and tissue redistribution are limited to the initial postoperative year for patients undergoing short-scar medial pedicle breast reduction. With the advent of 3D photography, plastic surgeons currently can objectively monitor the postoperative changes in breast morphology. Studies are underway to compare the changes in morphology over time with different techniques of breast reduction.

Conflict of interest Authors have no financial disclosures.

References

1. Strombeck JO (1964) Macromastia in women and its surgical treatment. Acta Chir Scand Suppl 341:1
2. Westreich M (1997) Anthropomorphic breast measurement: protocol and results in 50 women with aesthetically perfect breasts and clinical application. Plast Reconstr Surg 100:468–479
3. Meshulam-Derazon S, Barnea Y, Zaretski A, Leshem D, Miller U, Meilik B, Weiss J, Shafir R, Amir A, Gur E (2009) Large-volume breast reduction: long-term results. Scand J Plast Reconstr Surg Hand Surg 43:65–70
4. Ferreira MC, Costa MP, Cunha MS, Sakae E, Fels KW (2003) Sensibility of the breast after reduction mammaplasty. Ann Plast Surg 51:1–5
5. Dabbah A, Lehman JA, Parker M, Tantri D, Wagner DS (1995) Reduction mammaplasty: an outcome analysis. Ann Plast Surg 35:337–446
6. Rogliani M, Gentile P, Labardi L, Donfrancesco A, Cervelli V (2008) Improvement of physical and psychological symptoms after breast reduction. J Plast Reconstr Aesthet Surg 62:1647–1649
7. Eggert E, Schuss R, Edsander-Nord A (2009) Clinical outcome, quality of life, patients' satisfaction, and aesthetic results after reduction mammaplasty. Scand J Plast Reconstr Surg Hand Surg 43:201–206
8. Thoma A, Sprague S, Veltri K, Duku E, Furlong W (2007) A prospective study of patients undergoing breast reduction surgery: health-related quality of life and clinical outcomes. Plast Reconstr Surg 120:13–26
9. Brown AP, Hill C, Khan K (2000) Outcome of reduction mammaplasty: a patient's perspective. Br J Plast Surg 53:584
10. Abramson DL, Pap S, Shifteh S, Glasberg SB (2005) Improving long-term breast shape with the medial pedicle wise pattern breast reduction. Plast Reconstr Surg 115:1937–1943
11. Reus WF, Mathes SJ (1988) Preservation of projection after reduction mammaplasty: long-term follow-up of the inferior pedicle technique. Plast Reconstr Surg 82:644–650
12. Keck M, Kaye K, Thieme I, Ueberreiter K (2007) Vertical mammaplasty: postoperative changes, complications, and patient evaluation. Can J Plast Surg 15:41–43
13. Galdino GM, Nahabedian M, Chiaramonte M, Geng JZ, Klatsky S, Manson P (2002) Clinical applications of three-dimensional photography in breast surgery. Plast Reconstructr Surg 110:58–70
14. Tepper OM, Choi M, Small K, Unger J, Davidson E, Rudolph L, Pritchard A, Karp NS (2008) An innovative three-dimensional approach to defining the anatomical changes occurring after short scar medial pedicle reduction mammaplasty. Plast Reconstr Surg 121:1875–1885
15. Kevin S, Tepper OM, Unger JG, Kumar N, Feldman DL, Choi MH, Karp NS (2010) Redefining pseudoptosis from a 3D perspective after short-scar medial pedicle reduction mammaplasty. J Plast Reconstr Aesthet Surg 63:346–353
16. Karp NS (2004) Medial pedicle/vertical breast reduction made easy: the importance of complete inferior glandular resection. Ann Plast Surg 52:458–464
17. Choi MH, Unger JG, Small K, Tepper OM, Kumar N, Feldman DL, Karp NS (2009) Defining the kinetcis of breast pseudoptosis after reduction mammaplasty. Ann Plast Surg 62:518–522
18. Tepper OM, Small K, Rudolph L et al (2006) Virtual 3-dimensional modeling as a valuable adjunct to aesthetic and reconstructive breast surgery. Am J Surg 192:548–551
19. Fayman MS, Potgieter E, Becker PJ (2001) Outcome study: periareolar mammaplasty patients' perspective. Plast Reconstr Surg 111:676–684