INTRODUCTION

Anterior-posterior (AP) implant malposition or flipping as a complication of implant-based breast surgery became clinically relevant after the introduction of anatomical implants. Before this, breast implants were only available as round implants. AP flipping of round implants containing saline or cohesive silicone gel (ie, fourth-generation silicone gel implants) is generally not clinically discernible. Anatomical implants, in contrast, are teardrop shaped. These fifth-generation implants can retain their shape in any position as they consist of highly-cohesive, form-stable silicone gel. AP flipping of anatomical implants, thus, leads to breast shape distortion. Between 1% and 14% of breast augmentations have been reported to exhibit implant flipping.¹

Currently, form-stable implants are also available in round shape. These fifth-generation, round, form-stable implants differ from previous generation of round implants in having a higher cohesive gel and in having a higher fill volume.² These implants also have an anterior profile (round) that differs from the posterior profile (flat). Because of these implant features, AP flipping of round, form-stable implants can be discernible, as the anterior aspect of the breast will assume a flattened

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Disclosure: Allen Gabriel, MD, is a consultant for Allergan, Madison, N.J. All the other authors have no financial interest in relation to content of this article. No funds were received for this study.
appearance when flipped. Apart from a published report,\textsuperscript{3} AP flipping of round implants is a poorly studied complication of implant reconstruction.

The purpose of this study was to document the incidence of AP flipping associated with round, cohesive, form-stable implants; to identify risk factors for AP flipping; and to discuss corrective measures and best practices to prevent the occurrence of AP flipping.

**PATIENTS AND METHODS**

This is a retrospective study of consecutive patients who underwent breast surgery between November 2013 and November 2018 at Blount Memorial Hospital and the University of Tennessee Medical Center. All patients were operated by a surgical team consisting of a single breast oncologic surgeon (MT) and a single plastic surgeon (JTC). Patients who underwent single-stage, direct-to-implant reconstruction with round, cohesive, smooth implants were included in the study. Patients who underwent 2-stage reconstruction or who had anatomical or textured devices were excluded. As the study spans a 5-year period, it includes the surgical team’s evolution from skin-sparing mastectomy with submuscular reconstruction, to nipple-sparing mastectomy with prepectoral reconstruction. The study was approved by The University of Tennessee Health Science Center/Graduate School of Medicine Institutional Review Board.

**Data Collection**

Patient records were reviewed, and data on patient demographic characteristics [age and body mass index (BMI)], smoking status, neoadjuvant/adjuvant treatment, mastectomy characteristics (skin-sparing or nipple-sparing and mastectomy volume), reconstructive details [submuscular or prepectoral reconstruction, acellular dermal matrix (ADM) type and ADM coverage technique (inferior pole coverage, tenting, or wrapping)], incidence of AP flipping, and incidence of other complications were retrieved. AP flipping was clinically confirmed after breast shape deformity was reported by patients. Patients were stratified by presence or absence of AP flipping, and the retrieved data were compared between the groups to identify risk factors associated with AP flipping.

**Statistical Analyses**

Demographic characteristics of patients were analyzed using descriptive and frequency statistics. Chi-square statistics were used to compare independent groups on categorical outcomes. Unadjusted odds ratios with 95% confidence intervals were reported for statistically significant findings as a measure of strength of association. Continuous variable distributions were assessed for the statistical assumption of normality using skewness and kurtosis statistics. If either statistic was above an absolute value of 2.0, then the assumption was violated. Levene’s Test of Equality of Variances was used to test for the statistical assumption of homogeneity of variance. Independent samples t-tests were used to compare independent criteria on normally distributed continuous outcomes that met statistical assumptions. Means and SDs were reported and analyzed for all t-tests analyses. Statistical significance was assumed at an $\alpha$ value of 0.05, and all analyses were conducted using SPSS, version 25 (IBM Corp., Armonk, N.Y.).

**RESULTS**

A total of 117 patients met the inclusion criteria, and a total of 250 breasts were reconstructed (Table 1). Sixty-six patients underwent bilateral skin-sparing mastectomy, 47 underwent bilateral nipple-sparing mastectomy, 3 underwent unilateral nipple-sparing mastectomy, and 1 underwent unilateral skin-sparing mastectomy. In 59 patients (116 breasts), implants were placed submuscularly, and in 58 patients (114 breasts), implants were placed in the prepectoral space. Acellular dermal matrices (ADMs) were used in all reconstructions; AlloDerm (Allergan Plc, Bridgewater, N.J.) in 40 breasts and FlexHD (Musculoskeletal Transplant Foundation Biologics, Edison, N.J.) in 190 breasts. The choice of ADM was influenced by hospital supply/cost restrictions and not necessarily by surgeon preference. In submuscularly placed implants, ADM was used to cover the inferior pole of the implants. Prepectorally placed implants were wrapped (81 breasts) or tented (33 breasts) with ADM, as previously described.\textsuperscript{4} Over the 5-year study period, 16 cases of AP flipping were documented for a flip rate of 7.0% (Table 2). All

| Table 1. Baseline Demographic, Mastectomy, and Reconstructive Data |
|-----------------|----------------------|
| Variable        | Number |   |
| Patients        | 117     |
| Breasts         | 250     |
| Mastectomy (no. patients) | Bilateral  | 113 |
| Mastectomy (no. patients) | Unilateral | 4 |
| Mastectomy (no. patients) | Skin-sparing | 139 |
| Mastectomy (no. patients) | Nipple-sparing | 97 |
| Reconstruction (no. patients) | Submuscular | 60 |
| Reconstruction (no. patients) | Prepectoral | 57 |
| ADM (no. patients) | AlloDerm | 20 |
| ADM (no. patients) | FlexHD | 97 |
| ADM coverage (no. patients) | Inferior pole coverage | 50 |
| ADM coverage (no. patients) | Wrapping | 41 |
| ADM coverage (no. patients) | Tenting | 17 |

| Table 2. Incidence of AP Flipping and Other Complications |
|-----------------|----------------------|
| Complication    | n (% of breasts) |
| AP Flipping     | 13 (5.7) |
| Nipple-areolar necrosis | 19 (8.3) |
| Capsular contracture | 7 (3.0) |
| Periprosthetic infection | 5 (2.2) |
| Wound dehiscence | 4 (1.7) |
| Animation       | 4 (1.7) |
| Asymmetry       | 3 (1.3) |
| Hematoma        | 2 (<1) |
| Mastectomy skin flap necrosis | 2 (<1) |

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cases occurred in patients with prepectoral implants; none of the submuscularly placed implants flipped. Among other documented complications, nipple–areolar necrosis was the most frequently observed complication in this series at a rate of 8.3% followed by capsular contracture at 3.0%. Hematoma, wound dehiscence, periprosthetic infection, animation, asymmetry, and mastectomy skin flap necrosis occurred at a rate of <3.0%.

Comparative analyses of patients with and without AP flipping showed no statistically significant differences in age, BMI, implant volume, or ratio of mastectomy wound volume to implant volume between the groups (Table 3). Patients’ smoking status, type of adjuvant treatment received (chemotherapy or radiotherapy), or type of mastectomy (skin- or nipple-sparing) also did not differ significantly between the groups. In contrast, statistically significant differences were noted between patients with and without flipping for reconstruction type (prepectoral or submuscular), degree of implant cohesivity, ADM type used (AlloDerm or FlexHD), or ADM coverage technique (inferior pole, wrapping, or tenting) (Table 3). On univariate analysis, prepectoral reconstruction, highly cohesive implants, use of AlloDerm, and ADM wrapping/tenting techniques were found to be significantly associated with AP flipping, increasing the odds of AP flipping by 39-, 8.8-, 3.2-, and 39-fold, respectively (Table 4). To further assess the association between wrapping or tenting and AP flipping, univariate analyses were repeated among patients who underwent prepectoral reconstruction with the results indicating that neither tenting nor wrapping significantly increased the risk of AP flipping (Table 5). Moreover, neither AlloDerm nor FlexHD was a significant predictor of flipping within the prepectoral group. Logistic regression analyses further confirmed the lack of a significant association between ADM type and flipping ($P = 0.143$) when controlling for tenting/wrapping, despite a 2-fold higher incidence of AP flipping with AlloDerm versus FlexHD. Conversely, when controlling for ADM type, there was no significant association between wrapping or tenting and flipping ($P = 0.96$). These results suggest that the significantly higher incidence of AP flipping with prepectoral reconstruction is related to prepectoral implant placement rather than to the type of ADM used for implant coverage or the technique of ADM coverage. Because there were no cases of AP flipping in the submuscular group, the association between ADM type and flipping could not be assessed within this group.

**DISCUSSION**

Breast implants can theoretically flip along any axis. Flipping of fourth-generation, round, silicone implants is not normally clinically discernible because these implants contain a less-cohesive gel compared with fifth-generation round (or anatomic) silicone implants. The combination of highly cohesive gel together with higher fill volume makes the form of the fifth-generation round implants stable. Flipping or rotation of form-stable implants is discernible because these implants retain their shape or form irrespective of their orientation. Data on the extent of AP flipping with these implants and the factors contributing to flipping are limited.1

This study, undertaken at a single institution with a surgical team consisting of a single breast oncologic surgeon

**Table 3. Patient Demographic and Clinical Characteristics Stratified by AP Flipping**

| Variable                                      | No Flipping (n = 104) | Flipping (n = 13) | P   |
|-----------------------------------------------|-----------------------|------------------|-----|
| Age, years; mean (±SD)                        | 54.8 (10.6)           | 53.7 (13.6)      | 0.73|
| BMI, kg/m²; mean (±SD)                        | 29.9 (6.3)            | 29.7 (6.2)       | 0.94|
| Volume, mL; mean (±SD)                        | 591.3 (144.7)         | 640.8 (143.5)    | 0.25|
| Mastectomy wound volume to implant volume, mean (±SD) | 20.0 (4.1)          | 21.7 (4.2)       | 0.16|
| Smoker, no. patients (%)                      | 20 (19.2%)            | 0 (0.0%)         | 0.12|
| No                                            | 84 (81.8%)            | 13 (100.0%)      |     |
| Implant type, no. patients (%)                |                       |                  | <0.001|
| Least cohesive                                | 3 (2.9%)              | 2 (15.4%)        |     |
| Moderate cohesive                             | 2 (1.9%)              | 1 (7.7%)         |     |
| Most cohesive                                | 14 (13.4%)            | 8 (61.5%)        |     |
| Model 20                                      | 46 (44.2%)            | 1 (7.7%)         |     |
| Other                                         | 39 (37.5%)            | 1 (7.7%)         |     |
| ADM type, no. patients (%)                    |                       |                  | 0.009|
| AlloDerm                                      | 14 (13.5%)            | 6 (46.2%)        |     |
| FlexHD                                        | 90 (86.5%)            | 7 (53.8%)        |     |
| Mastectomy type, no. patients (%)             |                       |                  | 0.84|
| Skin sparing                                  | 59 (56.7%)            | 7 (53.8%)        |     |
| Nipple sparing                                | 45 (43.3%)            | 6 (46.2%)        |     |
| ADM coverage technique, no. patients (%)      |                       |                  | <0.001|
| Wrapping                                      | 33 (31.7%)            | 8 (61.5%)        |     |
| Tenting                                       | 12 (11.5%)            | 5 (38.5%)        |     |
| Inferior pole                                 | 59 (56.7%)            | 0 (0.0%)         |     |
| Treatment type, no. patients (%)              |                       |                  | 0.37|
| Chemotherapy                                  | 16 (15.4%)            | 2 (15.4%)        |     |
| Radiation                                     | 15 (14.4%)            | 0 (0.0%)         |     |
| Chemotherapy and radiation                    | 23 (22.1%)            | 2 (15.4%)        |     |
| Neither                                       | 50 (48.1%)            | 9 (69.2%)        |     |

Values in boldface are statistically significant.
and a single plastic surgeon, found an AP flip rate of 7.0% among a cohort of patients who underwent submuscular or prepectoral implant reconstruction. Importantly, all AP flipping occurred in patients who had prepectoral reconstruction. In addition, the use of highly cohesive implants was associated with a higher risk of AP flipping compared with less-cohesive implants. ADM type (AlloDerm or FlexHD) and ADM coverage technique (wrapping or tenting) did not appear to significantly impact AP flipping.

The absence of AP flipping with submuscular implant placement may not be surprising because the pectoral muscles provide sturdy implant support compared with thinned mastectomy skin and tissues and a layer of ADM that provide support to prepectoral placed implants. It should be noted that ADM use is important in both reconstructive techniques to reinforce the soft tissues at the inframammary fold and help prevent implant malposition. The use of ADM can also help limit wound volume relative to implant volume creating a hand in glove fit. However, if the ADM relaxes such that the hand in glove fit is lost, then excess room in the pocket may lead to AP malposition. The impact of ADM relaxation on AP flipping may be less critical in submuscular implants compared with prepectoral implants because the upper two-thirds of the implant is supported by the pectoralis major muscle.

In this study, 2 ADM types were used: AlloDerm and FlexHD. AP flipping occurred with both ADM types. Initial analysis suggested that the use of AlloDerm was associated with a higher risk of AP flipping. Logistic regression analyses, however, indicated that there was no significant difference in the risk of flipping between the two ADM types, despite a 2-fold higher incidence with AlloDerm. The numerically higher incidence of AP flipping with AlloDerm may be related to differences between the matrices in the extent of relaxation or stretching over time. It is likely that processing differences between FlexHD and AlloDerm could result in different stretch rates in vivo, which may help explain the numerically higher AP flip rate with AlloDerm. There is some evidence in the published literature that human acellular dermal matrix has the potential to stretch over time.5

Intuitively, one may think that tenting of ADM in prepectoral reconstructions may be associated with a higher risk of AP flipping than the ADM wrapping technique because there is less ADM coverage and support of the implant with tenting. Because the wrapping technique was utilized early in the senior surgeon’s experience and FlexHD was the only ADM available for use at this hospital, most of the wrapped implants received FlexHD. Additionally, as there was a numerically lower incidence of flipping with FlexHD, it was not clear whether ADM coverage technique or ADM type was contributing to AP flipping. Hence, a logistic regression analysis was performed controlling for ADM type, which indicated that neither the tenting or wrapping technique was significantly associated with AP flipping.

This study also found that a higher mastectomy wound volume to implant volume ratio did not appear to be associated with AP flipping, contrary to expectation. In a large mastectomy pocket, as in high BMI patients, the implant may be free to flip in an anterior to posterior direction. This was not the case in this series likely because of measures taken to ensure a tight pocket for the implant at the time of surgery.

The finding that higher cohesivity form-stable implants were associated with higher AP flip rates is also not surprising because the anterior and posterior surfaces of these implants have distinct profiles, making such flips more noticeable. As discussed above, earlier generation of implants (fourth generation), in contrast, have little difference in their anterior and posterior profiles; so AP flipping likely went unnoticed and was clinically insignificant. Anecdotally, however, AP flipping has been noted with earlier generation implants at the time of reoperation for unrelated reasons.

In summary, data from this study suggest that AP flipping is likely due to implant pocket stretching over time and/or utilizing highly cohesive implants in the prepectoral space. With this understanding, steps can be taken to prevent or mitigate AP flipping at each stage of the reconstructive process, including at preoperative planning, surgical intervention, and postoperative management, as outlined in Figure 1. In the event of AP flipping, treatment may include manual flipping (by the patient or the surgeon) or surgical intervention. Manual flipping can readdress implant orientation (Fig. 2), although it can be a painful process and flipping may recur if the implant pocket is stretched. Surgical intervention can address pocket stretch as well as implant cohesivity. Pocket stretch can be addressed in 2 ways: by tightening the loose skin envelope and by imbricating the pocket/ADM (Fig. 3) or by utilizing popcorn capsulorrathy with additional suturing to collapse the pocket,
if there is no necessity to tighten the skin envelope. In both cases after tightening the pocket, the highly cohesive implant may be retained. Alternatively, the highly cohesive implant may be exchanged for a less-cohesive implant after discussing with the patient the trade-offs of using each type of cohesive implant so that the patient is aware of the potential aesthetic outcome associated with the selected implant.

**Fig. 1.** AP flipping preventive measures.

**Fig. 2.** Nonsurgical manipulation to reorient flipped implant.
CONCLUSIONS

This study brings to light the previously underreported complication of AP breast implant malposition or flipping. AP flipping was associated with prepectoral placement of highly cohesive, form-stable, round, silicone implants. Neither ADM type (AlloDerm or FlexHD) nor ADM coverage technique (wrapping or tenting) was significantly associated with AP flipping. Future research will focus on documenting the rate of AP malposition with two-stage implant reconstruction, understanding the in vivo stretch characteristics of various ADM products, evaluating whether 3D mesh products may help stabilize mastectomy wound volume, and evaluating whether limiting form stability may help reduce visibility of AP malposition.

ACKNOWLEDGMENT

Writing and editorial assistance was provided by Kalanethee Paul-Pletzer, PhD.

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