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Breast

The SAEORA Flap for Prosthetic Breast Reconstruction: A Novel Flap Design without the Use of Acellular Dermal Matrices

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Background: The gold standard for implant-based breast reconstruction uses acellular dermal matrices (ADMs). They provide improved inferolateral pole coverage, reduced capsular contracture rates, and increased primary expander fill volumes. However, ADMs are costly and have been associated with increased rates of postoperative infection, seroma, hematoma, implant malposition, and mastectomy flap necrosis (MFN). This study describes a novel autologous flap without the need of ADM, the serratus anterior external oblique rectus abdominis (SAEORA) flap, as an alternative in prosthetic-based breast reconstruction.

Methods: A retrospective study was conducted on all patients who underwent SAEORA flap breast reconstruction by a single surgeon between January 1, 2013 and May 31, 2020 at a single institution. Patient demographics, diagnosis, treatment, tissue expander (TE) volume, implant size, complications, and results were assessed.

Results: Forty-seven patients underwent 78 SAEORA flaps. Sixty-two had TEs placed, and 14 were direct-to-implant. Mean body mass index was 23.1 kg per m^2. Median primary TE fill volume was 150 mL, and final implant volume average was 450 mL. Mean follow-up was 14.5 months. Complications included infection/cellulitis (7.9%), seroma (6.6%), hematoma (5.2%), and MFN (7.9%).

Conclusions: The SAEORA flap is a novel autologous flap and is a viable option for prosthetic-based breast reconstruction, with an acceptable complication profile relative to ADM-based reconstructions. Additionally, SAEORA is MFN-resistant and has been used effectively in salvage of exposed implants or ADM, and in double-bubble deformity correction. *(Plast Reconstr Surg Glob Open 2024; 12:e5852; doi: 10.1097/GOX.0000000000005852; Published online 21 June 2024.)*

INTRODUCTION

The incidence of breast cancer continues to increase globally.[1] Paralleling its rise in frequency, more women are undergoing prophylactic mastectomies,[2] with a preference toward implant-based breast reconstruction (IBBR). With this, a corresponding surge of breast reconstruction with acellular dermal matrices (ADMs) has occurred, accounting for the majority of alloplastic breast reconstruction in the United States.[3,4] ADMs are decellularized cadaveric tissue manufactured from various sources, including porcine; bovine; and, most commonly, human.

ADM attributes include faster expansion, reduced operating time, improved lower pole projection, reduced postoperative pain, and improved cosmesis.[4] However, ADM also has significant disadvantages. A major barrier to ADM includes cost, where a single sheet of ADM ranges from $2000 to $5000, according to size and thickness.[5–7] As a result, ADMs are not universally available to surgeons due to their significant expense. Additionally, various studies have reported equivalent[8–11] or increased[12–14] complication rates associated with the use of ADM. These include

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higher risk of infection, seroma, hematoma, mastectomy flap necrosis (MFN), and reconstructive failure.[12–15]

Given the high costs and postoperative complications of ADM use, viable autologous options have been described, demonstrating reduced major complications and comparable aesthetic outcomes and patient satisfaction.[16–18] In keeping with this, we describe a novel breast reconstruction technique that offers an effective method for immediate, delayed, or delayed-immediate prosthetic breast reconstruction without ADM. The serratus anterior external oblique rectus abdominis (SAEORA) turnover flap elevates the serratus anterior (SA), external oblique (EO), and rectus abdominis (RA) muscles from below the inframammary fold and is turned over cephalad to meet the pectoralis major (PM) muscle. This creates a markedly larger complete submuscular pocket, enabling placement of a definitive implant or tissue expander (TE) with larger primary fill volume upon insertion.

The objectives of this study were to describe the surgical technique of the novel SAEORA flap, document its complication profile, and demonstrate its functional and aesthetic outcome.

PATIENTS AND METHODS

A retrospective study was conducted on all patients who underwent SAEORA flap breast reconstruction for any reason (cancer, noncancerous, prophylactic) by the principal investigator between January 1, 2013 and May 31, 2020 at Kelowna General Hospital in Kelowna, British Columbia, Canada. The study was conducted in accordance with the ethical standards of the Declaration of Helsinki and was approved by the University of British Columbia (H20-01700).

Patient demographics, comorbidities, smoking status, body mass index, date of SAEORA surgery, total clinical time followed, operative details, adjuvant treatments, complications, and secondary procedures were recorded.

Inclusion criterion was any patient who underwent SAEORA flap reconstruction during the retrospective time interval. Exclusion criteria were previous chest wall surgery or injury between inframammary fold and costal margin (CM). All photographs and videos shown were obtained and approved for use in this study with patient written consent.

Statistical Analysis

Data are presented as means and medians with ranges. Statistical analyses were performed using Microsoft Excel, version 15.33 (Microsoft Corp. Redmond, Wash.). Study participants with incomplete data were not included in the analysis; the means and medians were adjusted accordingly.

SAEORA Applications

The SAEORA flap is most commonly used for TE-based breast reconstruction but may make direct-to-implant (DTI) reconstruction possible. It can also be used to salvage exposed implants or ADM, and to treat implant bottoming out and double-bubble deformities.

Takeaways

Question: Our study described a novel autologous flap, the serratus anterior external oblique rectus abdominus (SAEORA) flap, used for prosthetic breast reconstruction, as an alternative to ADM, given its associated cost and complication profile.

Findings: Retrospective chart review was completed of 47 patients who underwent immediate or delayed breast reconstruction using 76 SAEORA flaps. Our study detailed satisfactory aesthetic outcomes, complication profile rivaling ADM-based breast reconstruction, and utility in salvage procedures.

Meaning: The SAEORA is a novel autologous flap that can be used for prosthetic breast reconstruction with acceptable complication profile. Secondarily, it is effective in salvage of exposed devices/ADM and double-bubble deformity correction.

Surgical Technique

Key anatomical landmarks include inframammary fold (IMF), which is marked for reference, peri-xiphoid area (PXA), CM, and anterior axillary line (AAL). Flap markings are shown in Figure 1 along the CM from the PXA to its intersection with the AAL, then carried cephalad to intersection with the IMF laterally (Fig. 1).

Surgical positioning is supine with the arms abducted. Draping is undertaken to expose the surgical site from the clavicle superiorly, to the umbilicus inferiorly, and to the bed line laterally. Once supine, the previous markings and anatomical landmarks are confirmed, in particular the CM, as it may translocate cephalad during positioning. (**See figure, Supplemental Digital Content 1**, which shows the CM marked in blue from the PXA medially to the AAL laterally. **http://links.lww.com/PRSGO/D237**.)

After the mastectomy is completed, a subpectoral pocket is created to the medial extent of the IMF, avoiding transgression of the RA muscle and overlying fascia. Laterally, PM elevation extends to the AAL, leaving the superolateral pectoral fascial attachments to the chest wall intact. Within the surgical pocket, the IMF is then inked at the convergence of the mastectomy flap and the chest wall for future reference at the time of flap rotation and IMF repair. (**See figure, Supplemental Digital Content 2**, which shows a subpectoral pocket being created, and the inframammary fold being marked internally for later repair. **http://links.lww.com/PRSGO/D238**.)

The IMF is then transgressed, and the anterior thoracic soft tissues are elevated off the deep fascia overlying the RA, EO, and SA, extending to the CM from the PXA to the AAL. (**See figure, Supplemental Digital Content 3**, in which the IMF is transgressed, and dissection proceeds to the CM and AAL. **http://links.lww.com/PRSGO/D239**.)

Thereafter, the muscle flap is incised along or above the CM to prevent inadvertent entrance into the thoracic or abdominal cavity, which can be facilitated by bending the cautery tip 30–90 degrees. Medially, the incision courses through the anterior rectus sheath and splits the RA muscle longitudinally, leaving the posterior rectus

sheath intact, and then proceeds along the CM from the PXA to the AAL (Fig. 2). Along the AAL, the incision is best undertaken from cephalic to caudal, beginning at its intersection with the IMF and extending caudally to the level of the CM. This prevents upward retraction of the flap by maintaining the inferior points of attachment. Lateral flap length is essential, as it needs to be longest at this location when reflected cephalad, to meet the corresponding lateral PM margin.

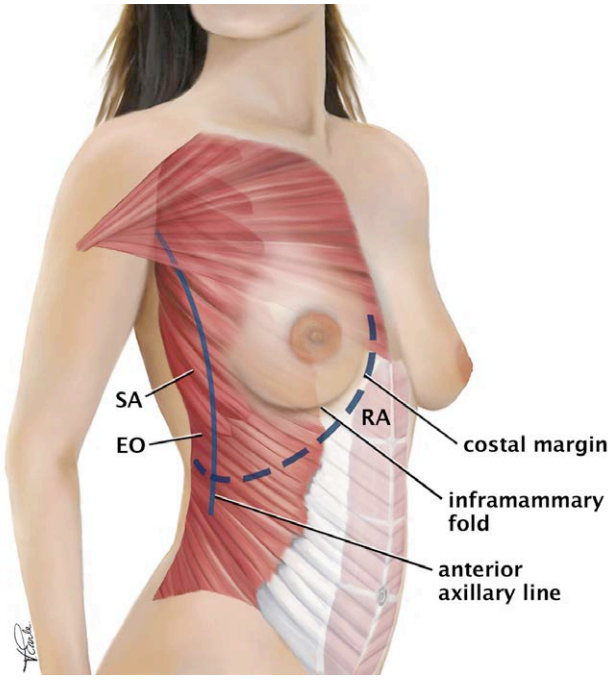

Fig. 1. Anatomic landmarks and components of the SAEORA flap.

After bringing the AAL incision into continuity with the CM incision, the flap is elevated off the underlying chest wall, beginning from medial to lateral and then caudal to cephalad. The dissection plane underneath the RA, EO, and SA is relatively hypovascular medially and inferiorly. The EO and SA slips are elevated off the underlying ribs in a subperiosteal plane. Flap elevation continues superiorly to the IMF reflection arc, which was previously marked on the chest wall before the IMF was transgressed. In approaching this, care is taken to preserve the uppermost intercostal perforators supplying the EO musculature and the superior epigastric artery and vein, if visualized. (**See figure, Supplemental Digital Content 4**, in which the SAEORA flap is incised and elevated superiorly to the level of IMF and is then reflected cephalad. **http://links.lww.com/PRSGO/D240**.)

The flap is then rotated cephalad to meet the PM. At the donor site, hemostasis is ensured, and a drain is placed. The previously marked internal surface of the curvilinear IMF is then repaired to the base of the superiorly rotated SAEORA flap with a running 2-0 tensile strength barbed suture to reconstitute the IMF. This is best done before placement of the device to avoid it being injured. Typically, flap elevation and donor site repair take approximately 20 minutes (Fig. 2). (**See figure, Supplemental Digital Content 5**, which shows the SAEORA flap rotated cephalad to meet the PM over the implant. **http://links.lww.com/PRSGO/D241**.) (**See figure, Supplemental Digital Content 6**, in which the SAEORA flap is sutured to the PM muscle and lateral chest wall. **http://links.lww.com/PRSGO/D242**.)

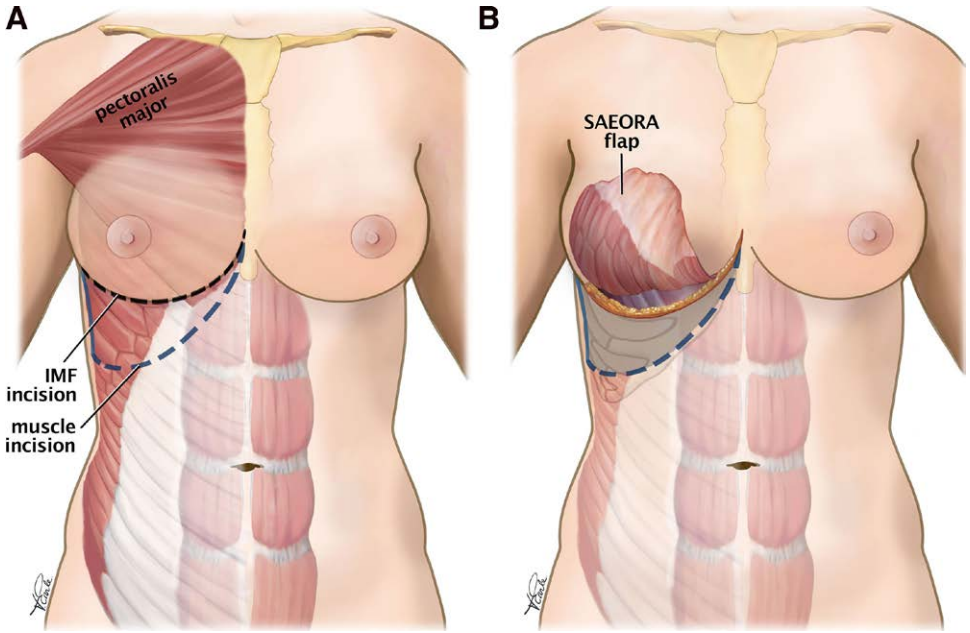

Fig. 2. The SAEORA flap is incised and elevated to the level of the IMF (A), then reflected cephalad (B). The IMF is then repaired to the base of the flap.

The implant or TE is then placed subjacent to the PM and the SAEORA flap is rotated cephalad over the device to meet the inferior margin of the PM. The SAEORA flap is sutured to the PM with a running 2-0 tensile strength barbed suture (Fig. 3). Repair begins centrally on the axis of the breast meridian and is carried medially to the chest wall at the medial extent of the IMF. Laterally, the repair extends to the AAL, and then the SAEORA flap is repaired to the chest wall along the AAL extending from the level of the PM to the lateral extent of the IMF. This effects complete muscular coverage of the device as well as lateral pocket control (Fig. 4). A drain is placed in the submuscular pocket, and the breast flaps are repaired.

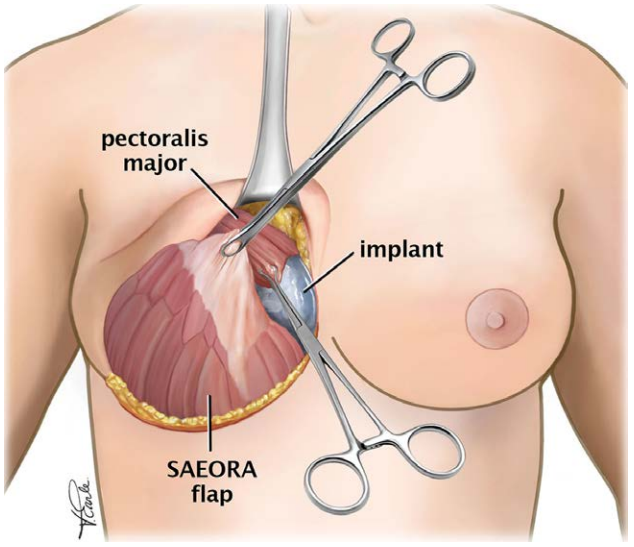

Fig. 3. The SAEORA flap rotated cephalad to meet the PM over the implant.

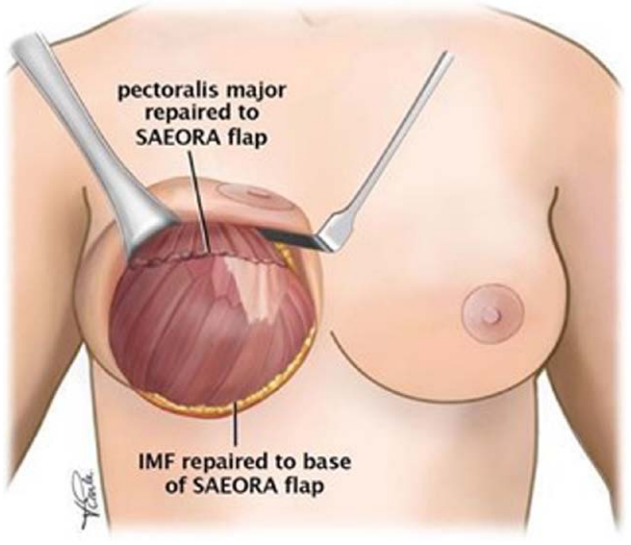

Fig. 4. The SAEORA flap is sutured to the PM and lateral chest wall.

RESULTS

Demographics

Forty-seven patients received 76 SAEORA flap reconstructions by a single surgeon, between January 1, 2013 and May 31, 2020. Average follow-up time was 13.19 months (0.69–53.42). Patient demographics, comorbidities, indications, adjuvant therapy, surgical management, and follow-up are listed in Supplemental Digital Content 7 (**See table, Supplemental Digital Content 7,** which shows the demographics of patients undergoing mastectomy with SAEORA flap reconstruction. **http://links.lww.com/PRSGO/D243**.) Average age was 52.8 (23.8–78.9) years. The average BMI was 23.1 kg per m^2 (18.6–40.0). Comorbidities were present in 13 (27.66%) patients. The indication for the procedure was for prophylactic (n = 37; 48.68%), invasive cancer (n = 19; 25.00%), in situ disease (n = 16; 21.05%), and noncancerous (n = 5; 6.58%) reasons. Sixty-five (85.53%) procedures were immediate, and 11 (14.47%) were delayed in timing. (**See table, Supplemental Digital Content 7, http://links.lww.com/PRSGO/D243**.)

Complications

Surgical site complications are listed in Supplemental Digital Content 7 (**http://links.lww.com/PRSGO/D243**). Six flaps (7.9%) had infections requiring surgical debridement. Six flaps (7.9%) had MFN. Four flaps (5.2%) had hematoma, and five flaps (6.6%) had seroma. Five flaps (6.6%) had prosthesis loss, and one patient developed an epigastric hernia (1.3%)

TE and Implant Volumes

For immediate and delayed SAEORA breast reconstruction, average initial TE fill volumes were 150 mL, and final TE fill volumes 450 mL. Average time for TE-implant exchange was 204 days for immediate, and 163 days for delayed SAEORA breast reconstruction. Final median implant volume was 500 mL (180–800) for immediate and 550 mL (450-650) for delayed SAEORA reconstruction. For the DTI group, final median implant volume was 320 mL (250–500). (**See table, Supplemental Digital Content 8,** which shows the primary, interval and final volumes of TEs and implants. **http://links.lww.com/PRSGO/D244**.)

Functional and Aesthetic Outcomes

Typical results are demonstrated in Figures 5–6A, and in Supplemental Digital Contents 9 and 10. (**See figure, Supplemental Digital Content 9,** which shows a 53-year-old, B/L SSM, immediate reconstruction patient, TE -> 600 mL-implants, 6 years postoperative. **http://links.lww.com/PRSGO/D245**.) [**See figure, Supplemental Digital Content 10,** which shows a 25-year-old patient who received left nipple-sparing mastectomy with immediate DTI 350mL HP device, before (left) and 1-year postoperative (right). **http://links.lww.com/PRSGO/D246**.]

DISCUSSION

The SAEORA flap can be used in immediate or delayed breast reconstruction, allowing for reasonable

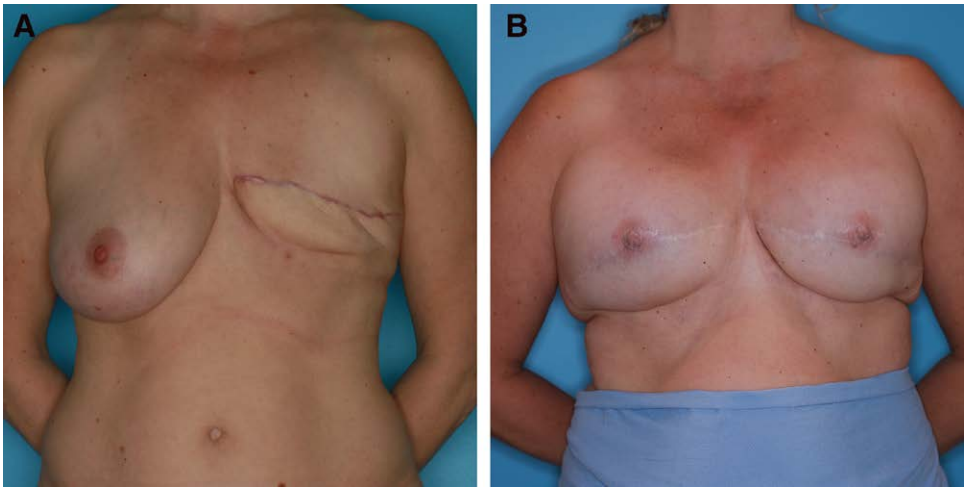

Fig. 5. A 49-year-old patient with L-delayed and R-immediate SAEORA reconstruction. TE to 550-mL implants. A, Preoperative image. B, Postoperative image.

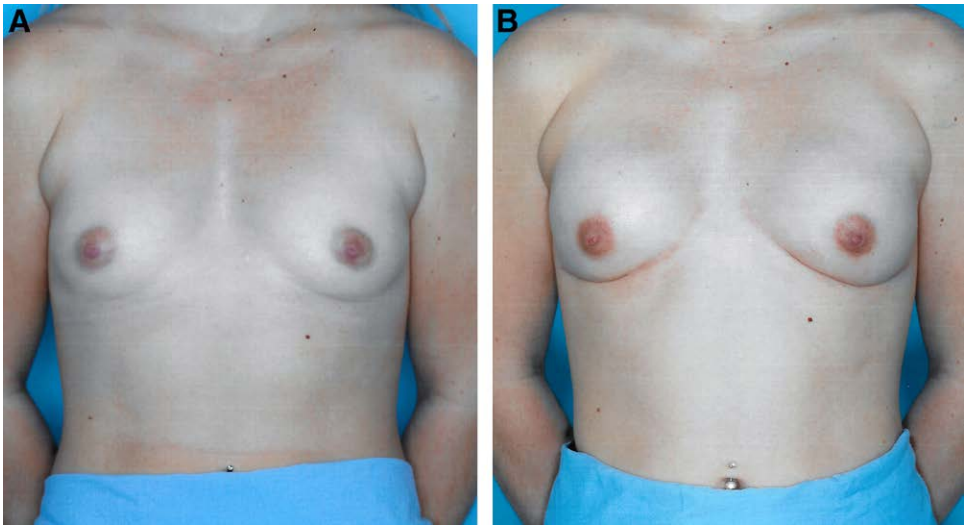

Fig. 6. A 23-year-old patient with bilateral prophylactic nipple-sparing mastectomy with immediate DTI with a 250-mL high-profile device. A, Preoperative image. B, Postoperative image.

average median primary and final TE fill volumes (150 mL, and 450 mL respectively), as well as median DTI sizes (average: 320 mL). The SAEORA flap has an acceptable complication profile that is similar to complication rates cited in the literature for ADM-based alloplastic reconstruction with minimal donor site morbidity.

The predominance of TE (81.6%) versus DTI (18.4%) in this study reflects a time when DTI was less popular, and the capabilities of the flap were being defined. A shift to DTI has since occurred, and generally, implants up to 450 mL can be accommodated primarily, assuming the mastectomy flaps are able.

Currently, IBBR with the adjunct of ADM is the gold standard in breast reconstruction. ADM has been used to cover the inferolateral portion of the implant that cannot be covered by the PM muscle as an alternative to traditional complete submuscular coverage, which can result in a tight inferior pole and poorly defined/positioned IMF. However, ADM methods have several drawbacks, including high cost and surgical complications.

Several studies[5,9,10,19] that compared the cost-effectiveness of using ADM in IBBR have reported conflicting data. This may be explained by the different cost-analysis methodologies and differences in healthcare financing among different countries. A prospective multicenter RCT compared the cost of one-stage IBBR with ADM with two-stage IBBR without ADM at eight hospitals in the Netherlands.[9] This study showed that the direct costs of one-stage IBBR with ADM were higher than those of two-stage reconstruction without ADM, and health outcomes did not differ between the groups.

Studies have reported higher complication rates with the use of ADM. In 2012, a systematic meta-analysis

reviewed 16 retrospective studies from 1966 to 2010 that examined one-stage and two-stage IBBR with or without the use of ADM. Overall, the ADM group had a significantly higher complication rates compared with the non-ADM group, such that the seroma formation rate quadrupled, and the infection and reconstructive failure rates tripled.[13]

The ideal soft-tissue cover would be easily harvested, of minimal morbidity and cost, and preferably autologous. To achieve this goal, surgeons have devised various surgical techniques to include the fascia and musculature caudal to the breast to cover the inferolateral portion of the implant.

Bohmert described using a turnover flap of an upper segment of the RA (full breadth) and EO to bridge over the weak regions of the thin muscle layer in the lower pole of the breast.[21] The study reported good overall outcomes except in two of 63 cases, where the flap was used for bilateral reconstruction. Both patients developed back pain, and one developed a hernia in the epigastrium, which resolved after the flaps were transferred back to their previous position. The authors concluded that removal of the RA and EO muscles bilaterally can cause a hernia and truncal instability, and thus, the flap was only recommended for unilateral reconstructions. Similarly, we had a single case where the patient developed an epigastric hernia after bilateral reconstruction with SAEORA flap when an overzealous harvest of the RA was performed during our early experience. The hernia in this study was repaired with an allograft mesh, and there was no need to reverse the flap.

Some studies recommend using fascial flaps instead of muscle to minimize donor site morbidity. Isken et al described a technique in which they harvested the fascia of the RA and EO to cover the lower pole of the implant.[20] They found that when raised as a unit, both the RA and EO fascia can provide enough tissue to allow for complete implant coverage without significant alteration of the important inframammary sulcus. Kim et al[17] similarly described a method in which they used the conjoined fascia of the PM, SA and EO muscles to cover the lower third of the implant. However, both studies were quite small ($n < 12$), making it hard to assess complication rates. The main limitation of using fascial flaps is their lack of availability and/or reliability in certain patients.

To address the problems associated with ADM, fascia only, and other muscle flap variants the SAEORA flap was devised, which can provide total muscle coverage of the implant at the time of mastectomy. This technique affords a natural breast shape and adequate implant coverage without the use of ADM (Figs. 5–6; **Supplemental Digital Content 9, http://links.lww.com/PRSGO/D245**). The implant pocket created results in a well-defined and symmetrical rounding of the inferior pole over IMF with little or no donor site contour deformity. (**Supplemental Digital Content 10, http://links.lww.com/PRSGO/D246**). Indeed, in the PI's experience, the SAEORA flap provides robust control of implant position, both inferiorly and laterally, as well as IMF position and definition.

Although not formally studied, donor site morbidity seems well tolerated with analgesia requirements similar to those of mastectomy and TE alone. Drains are typically in place for about a week. Patients typically report achiness or numbness for a few months, with return to functional baseline along a similar timeline. No patients have cited any concerning contour deformities. Further, sacrifice of the RA pedicle with the split muscle harvest occurs in roughly 20% of cases, thus leaving the possibility of pedicled TRAM reconstruction in most cases (**Supplemental Digital Content 10**, **http://links.lww.com/PRSGO/D246**).

Complication rates in this series are similar to those in reports using ADM.[13,22,23] However, it is difficult to compare complication rates between studies because there are various confounding factors that make generalization problematic.

In terms of costs, the SAEORA approach is likely much less expensive than ADM. Based on a rudimentary analysis in this series, the cost of ADM minus the SAEORA flap fee resulted in an approximately $4000 savings per breast, or approximately $300,000 in this study. This excludes the cost of care for secondary complications. However, a formal cost–benefit analysis study comparing these approaches would be beneficial. Thus, in settings where financial and technological restraints make ADM unavailable, the SAEORA flap can be an affordable and safe alternative.

Additional applications of the SAEORA muscle flap include correction of double-bubble deformity and bottoming out (Fig. 7A). (**See figure, Supplemental Digital Content 11,** which shows pre- and post-double-bubble deformity correction utilizing the SAEORA flap. **http://links.lww.com/PRSGO/D247**.) The SAEORA flap elevation violates the native IMF initially but reconstructs the IMF strongly and precisely as it is sutured to the base of the superiorly rotated SAEORA, which supports the device. Furthermore, the SAEORA flap has been used successfully as a salvage technique for alloplastic reconstructions complicated by ADM or device exposure, as it enables surgeons to obtain viable autologous tissue outside the breast borders for coverage, without loss of the reconstructive device, or the morbidity of a latissimus or free flap (Fig. 8). Lastly, the SAEORA flap is MFN-tolerant, allowing for healing by secondary intention or skin grafting without device loss (Fig. 9).

LIMITATIONS

Flap Limitations

Limitations of the SAEORA flap include that no skin paddle is available. It may also be more prone to postmastectomy radiation fibrosis relative to prepectoral placement, as is the case with subpectoral devices. Also, as the device is still subpectoral, animation motion can occur, although it seems less than with subpectoral alone. Perhaps this is because the PM is anchored against window-shading

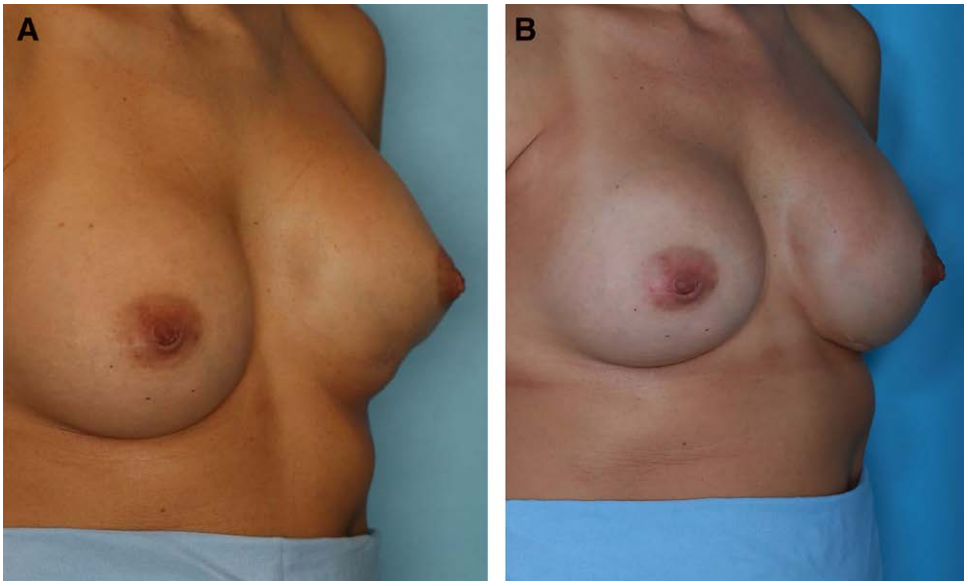

Fig. 7. Double-bubble deformity correction using the SAEORA flap. A, Preoperative photograph. B, Postoperative photograph.

Fig. 8. Exposed ADM/implant salvage with an SAEORA flap elevated and repaired over the device intraoperatively. A, Exposed ADM after attempted local closure. B, SAEORA flap elevated and repaired over replacement device. C, Breast flap advancement and repair. D, Four months postoperative breast photograph of the patient.

over the device and/or there is less adhesion between the PM edge and the undersurface of the mastectomy flaps. An ideal alternative may be to cover the inferior pole of the device with an SAEORA flap and the upper pole with mesh or ADM to capitalize on its advantages without animation issues.

Fig. 9. MFN over SAEORA flap, with secondary healing and implant preservation. Scar revision was performed later. A, Mastectomy flap necrosis. B, Eschar sloughed off over underlying SAEORA flap. C, Secondary healing complete with resultant scar. D. Post scar revision.

Study Limitations

Despite the study including procedures by a single surgeon at a single site over 8 years with a relatively large participant size, this study is retrospective and is dependent on the limitations of a retrospective review. In addition, a control group is not present. Future prospective studies with control groups would further elucidate complications rates and should include patient satisfaction with aesthetic and functional outcomes and a formal cost–benefit analysis.

CONCLUSIONS

Alloplastic breast reconstruction with ADM is the current preferred technique for breast surgeons. However, cost and associated complication rates limit its usefulness. We describe a novel autologous turnover flap called the SAEORA flap, which provides a successful breast reconstruction technique with complication rates at least similar to those of ADM. The SAEORA flap has been shown to be a safe, reliable, and aesthetic alternative to ADM. It has also been effective in double-bubble deformity correction and salvage of exposed ADM or device, and is tolerant to MFN.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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