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New Applications of the Anterior Intercostal Artery Perforator Flap for Prosthetic Breast Reconstruction in the Setting of Postoperative Radiotherapy

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Background: Several studies have reported preliminary experiences with the anterior intercostal artery perforator (AICAP) flap for treating partial breast defects or breast implant exposure following reconstruction. As radiotherapy is commonly administered for breast cancer, some patients may present with heavily damaged skin flaps and chronic radiodermatitis. We describe new applications of a de-epithelialized AICAP flap, used in combination with an implant, for breast reconstruction when other treatment options are unavailable.

Methods: A retrospective study was conducted, including all patients who underwent implant-based breast reconstruction with the aid of an AICAP flap. A literature review was also performed.

Results: Between November 2022 and August 2023, four pedicled AICAP flaps were harvested in four patients. The indications were breast implant coverage in cases of chronic dermatitis of the mastectomy skin flaps (two unilateral flaps) and inferolateral coverage of partially submuscular expanders for immediate breast reconstruction (two unilateral flaps). All four flaps were based on one perforator. The mean harvesting time was 40 minutes. Complete flap survival was achieved, with no complications at the donor site.

Conclusions: The AICAP flap is a safe and reliable technique for difficult cases of breast reconstruction when no other options are available. Moreover, this technique can easily provide additional coverage for the breast implant when needed.
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INTRODUCTION

Since the "Gent Consensus" in 2002, perforator flaps have been classified according to their nutrient artery.[1] In the lower nine intercostal spaces, a vascular arcade courses from the aorta to the internal mammary vessels or its branches. Generating the intercostal vascular arcade, the anterior intercostal artery communicates with the posterior intercostal vessel at the level of the anterior third of the rib. A vein of similar diameter accompanies the artery just above it while the nerve usually lies below the artery.[2]

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The intercostal artery perforator flap uses the same intercostal neurovascular bundle that is characteristic of the intercostal myocutaneous flaps.[3] The perforator flap technique allows for the transposition of the desired skin paddle, preserving muscular structures. Furthermore, a significant benefit of intercostal artery perforator flap over other perforator flaps in breast reconstruction is their ability to be moved as sensory flaps, incorporating the intercostal nerve that comes with them.[4]

As previously described, the course of the vascular arcade can be easily divided into four segments: vertebral, intercostal, intermuscular, and rectus segments.[2] The classification of flaps is determined by the origin of their perforators, as follows[4]: the dorsal intercostal artery perforator (DICAP) flap uses perforators originated from the vertebral segment of the intercostal vessels; the lateral intercostal artery perforator (LICAP) flap is based on perforators from the costal segment of the intercostal vessels; the anterior intercostal artery perforator (AICAP) flap uses perforators from either the muscular or rectal segment of the intercostal vessels (Fig. 1).

Disclosure statements are at the end of this article, following the correspondence information.

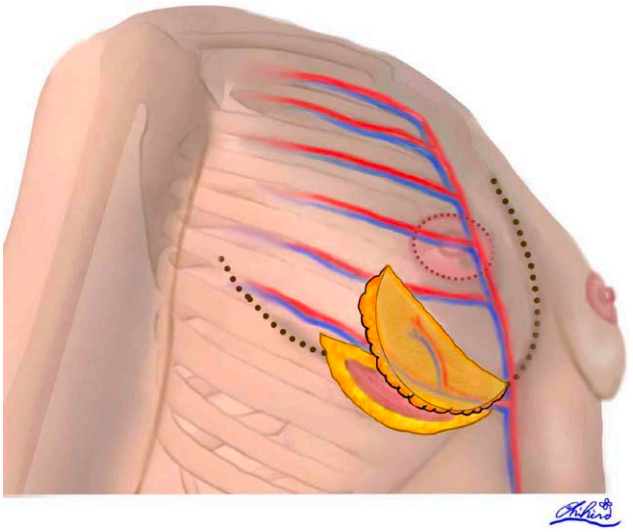

Fig. 1. Anatomy of the AICAP flap. Usually, perforators to the skin arise from the anterior intercostal artery and pierce the rectus muscle and deep fascia. At this level, they can be safely visualized and dissected for flap elevation.

In breast reconstructive surgery, flaps based on lateral (LICAP) or anterior (AICAP) perforators of the intercostal artery are implemented. Esteemed for its simplicity and reliability, the AICAP flap serves as an efficacious option for volume restoration in immediate partial breast reconstructions postquadrantectomy. This method is favored for its good aesthetic outcomes and notably lower morbidity rate when compared with traditional myocutaneous flaps.[4]

Several studies reported preliminary experiences with the AICAP flap for the treatment of partial breast defects[5–8] or breast implant exposure following reconstruction. For the latter, the AICAP flap has been shown to be a useful alternative, obtaining, in many cases, breast implant salvage following exposure.[9] Even if this useful technique has been described, breast implant removal and delayed breast reconstruction is routinely the procedure of choice when the implant is exposed.[10]

The objective of this research was to report our experience on the utilization of the AICAP flap in conjunction with tissue expanders and implants for breast reconstruction in the setting of postoperative radiotherapy. As radiotherapy is commonly administered for breast cancer, some patients may present heavily damaged skin flaps and chronic radiodermatitis. We describe new applications of a de-epithelialized AICAP flap, used in combination with an expander/implant, for breast reconstruction.

MATERIALS AND METHODS

A retrospective study was conducted among patients who underwent radiotherapy and showed radiation-induced dermatitis at the time of intervention. Every patient who had implant-based breast reconstruction with an AICAP flap was included in this study.

Takeaways

Question: Is the AICAP flap a safe treatment option for patients undergoing postoperative radiotherapy?

Findings: In our experience, none of the patients treated with the AICAP flap developed implant exposure.

Meaning: The AICAP flap is a straightforward, safe, and aesthetically pleasing procedure that does not require additional incisions beyond the inframammary fold.

The patients were informed about the procedure and its associated risks, as well as possible treatment alternatives. Alternatives such as fat transfer and autologous flaps were discussed but were discarded by the surgeon following patient examination. Inclusion criteria were body mass index less than 40 kg per m^2, previous radiotherapy with or without radiation-induced dermatitis, and ineligibility for autologous breast reconstruction.

The study adhered to the Declaration of Helsinki of 1964 (revised 2008), and Policlinico Umberto I University Hospital, Sapienza University of Rome Institutional Ethics Committee approval was obtained. Written informed consent was obtained from all participating patients before the procedure.

Patients were evaluated preoperatively and at 1-, 3-, and 6-months follow-up. Complications such as total flap necrosis, acute bleeding, hematoma, seroma, implant exposure, inframammary fold rupture, and inframammary fold asymmetry were evaluated. The patient was informed preoperatively of the possibility of inframammary fold asymmetry in the postoperative period.

Flap viability was assessed in both inpatient and outpatient settings, with a hand-held unidirectional Doppler detecting arterial and venous signals along the flap pedicle. A flap was considered viable if a good signal was detected during follow-ups. A literature review investigating the use of the AICAP flap was also performed.

SURGICAL TECHNIQUE

The perforators of the anterior thoracic wall were located using a unidirectional Doppler in all cases. Perforator mapping began within 1–3 cm lateral to the sternal border and ended at the anterior axillary fold, extending 5 cm below the inframammary fold. The flap was then designed around the perforator below the native inframammary fold based on hand-held Doppler findings and skin laxity. The inframammary fold incision was made first to explore the perforators and to facilitate easy elevation of the flap. Once all the perforators in the mapped area were visualized in the subfascial plane, the AICAP flap was harvested in a lateral to medial direction in all the cases (Fig. 2). Two or three perforators for each intercostal space are commonly present. Initially, all the perforators were preserved, but when further mobilization of the flap was necessary, the most medial perforator was preserved and skeletonized

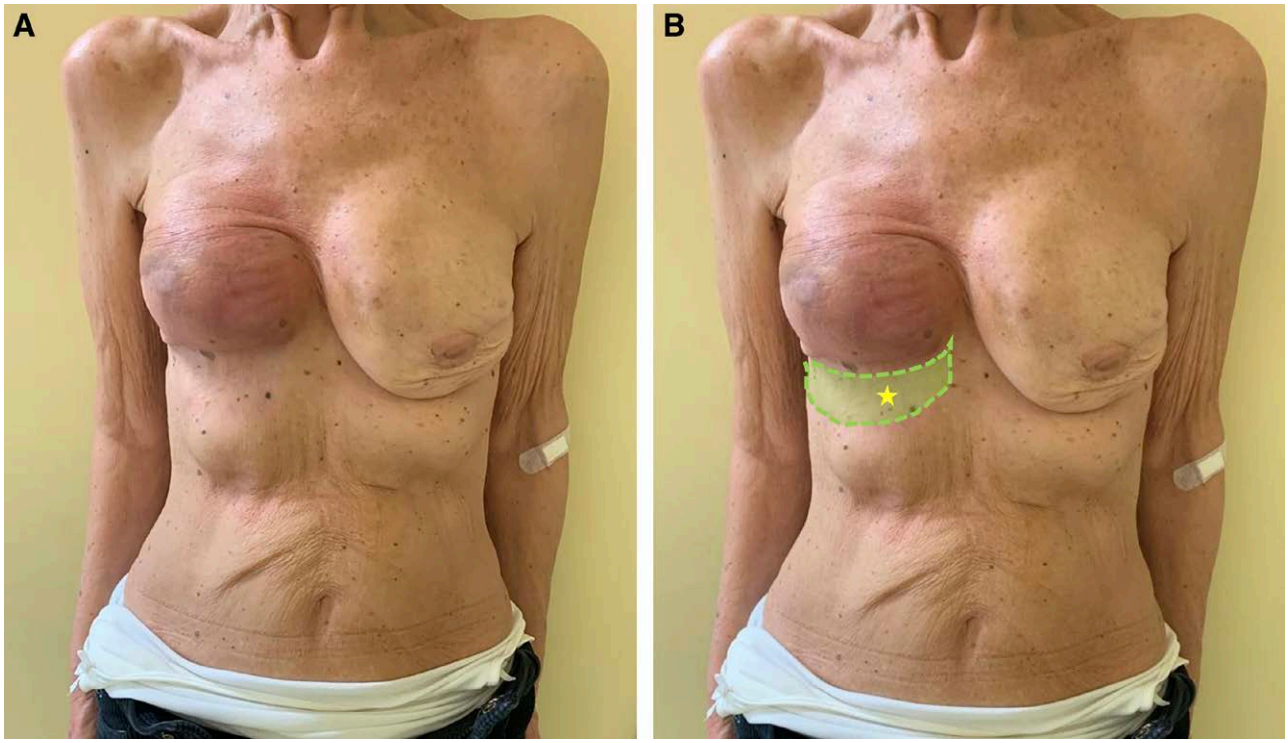

Fig. 2. Shield flap. A, Patient with severe capsular contracture of her reconstructed right breast. B, A large area of radiation-induced dermatitis is noted. The main perforator in the inframammary area is visualized (yellow star) and the AICAP flap is drawn (green-colored area).

through the muscle after intraoperative Doppler evaluation. Once adequate length was reached, the flap was transposed to the recipient area, de-epithelialized, and fixed with resorbable sutures. In our experience, flap dimensions may reach 19 × 8 cm. Typically, based on our experience, a 2- to 3-cm undermining of the inframammary area is adequate for achieving optimal closure and repositioning of the inframammary fold. Inframammary fold reconstruction was performed using 1-0 Vicryl interrupted sutures between the abdominal flap and the thoracic wall, with three to four sutures in all cases. A drain was always placed in the implant pocket, and slight compression applied over the reconstructed breast. Amoxicillin + clavulanic acid (1 g/8 h) was administered as antibiotic regimen until drain removal.

Two novel surgical applications of the AICAP flap are described as follows.

Shield Flap

After identifying the anterior perforator on the chest wall with a hand-held Doppler, the flap was drawn in the inframammary region in a half-moon shape. The skin was incised, the predefined area de-epithelialized, the flap sculpted, and the main perforator identified and isolated. The perforator was then dissected and skeletonized, and the flap mobilized (based only on the perforator) cranially (Fig. 3). The thinner skin area of the mastectomy flap previously treated with radiotherapy and at high risk of skin ulceration and prosthetic exposure was identified, and the AICAP flap inset by anchoring with 2/0 Vicryl stitches to the posterior aspect of the mastectomy flap itself. Breast reconstruction then proceeded with the positioning of a breast implant, ensuring the preservation of the pedicle of the AICAP and preventing the breast implant from bearing down on the pedicle (Fig. 4). In most scenarios, selecting a smaller implant is necessary to lessen the pressure on the radiated mastectomy flap. Moreover, the final volume of the reconstructed breast is determined by the combined contribution of both the implant and the AICAP flap, not solely by the implant.

Such a flap, referred to as a "shield flap," provides additional coverage to the breast implant at the zones of the mastectomy flap that are thinned and damaged by the previous radiotherapy and at higher risk of implant exposure, interposing the flap itself between the breast implant (posteriorly) and the mastectomy flap (anteriorly; (Fig. 5). Usually, such patients exhibit an elevation of the inframammary fold as for capsular contracture, induced by radiotherapy, of the expander/implant.

Total Autologous Periprosthetic Pocket

In selected patients, the AICAP flap was set up similarly and transferred cranially to the mammary region to create a totally autologous periprosthetic pocket, formed supero-medially by the pectoralis major muscle and inferolaterally by the AICAP flap itself. This method allowed the formation of a completely autologous pocket, by using the AICAP flap as inferolateral coverage to the implant, without the need to dissect muscles like the serratus anterior or rectus abdominis muscle or fascia and without requiring biological dermal matrices to supplement the pocket (Figs. 6 and 7).

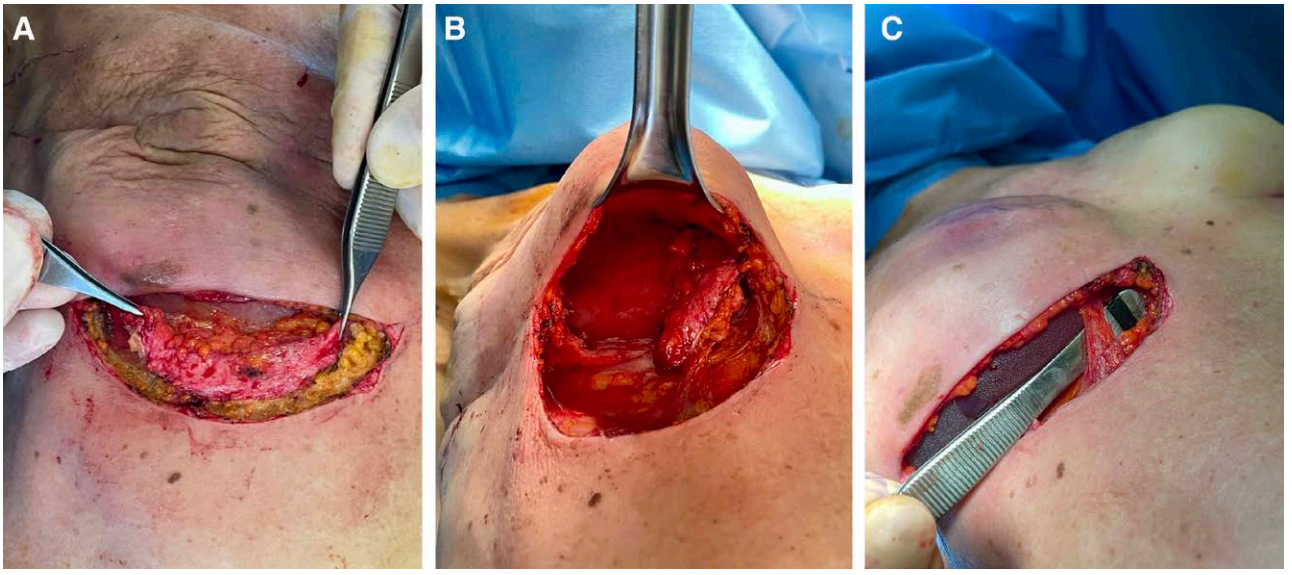

Fig. 3. Shield flap. A, A 15×4 cm AICAP flap is harvested from the inframammary fold. The perforator is located in the medial side of the flap. B, The flap is positioned under the damaged area of the skin flap and sutured superior and medial to it. C, The pedicle is skeletonized down to the muscle to maximize its length.

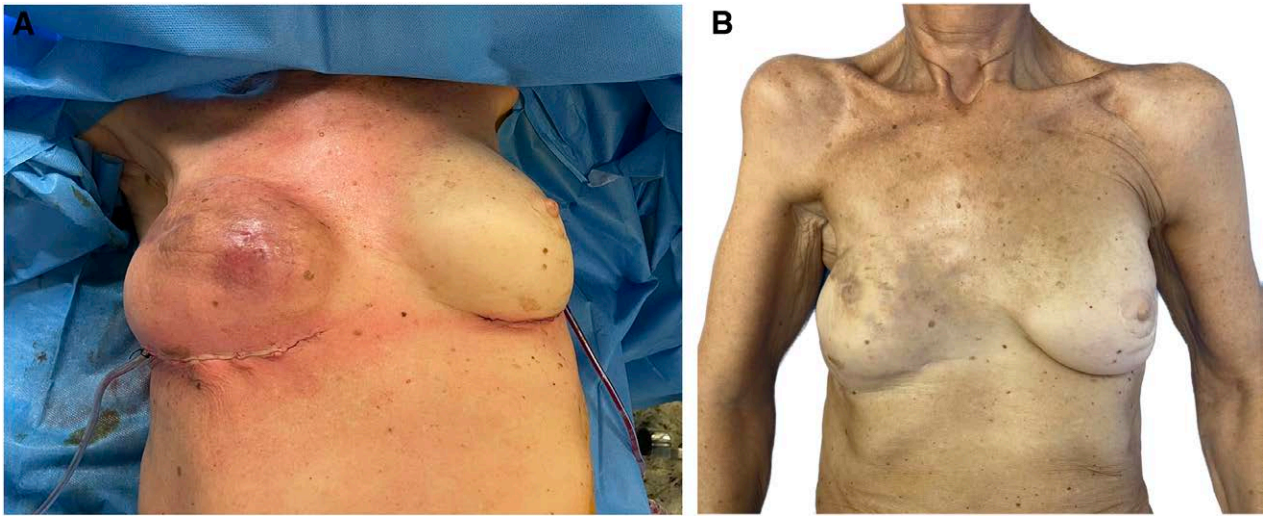

Fig. 4. Shield flap. Immediate (A) and 10-month follow-up (B) postoperative result with no signs of implant exposure and redness reduction of the area overlying the flap.

RESULTS

Between November 2022 and August 2023, AICAP pedicled flaps were performed in four patients for breast implant coverage in cases of chronic dermatitis of the mastectomy skin flaps (two unilateral flaps) and inferolateral coverage of partially submuscular expander for immediate breast reconstruction (two unilateral flaps).

Of these, three patients underwent nipple-sparing mastectomy and one patient received modified radical mastectomy. All patients had previously undergone radiotherapy and presented with radiation-induced dermatitis at the time of intervention. The patients had a history of breast surgery (three quadrantectomies and one mastectomy). The mean age of the patients was 71 years (range 63–82). For shield flap procedures, the implants were positioned in a submuscular position, leveraging the existing submuscular pockets. When creating the totally autologous periprosthetic pockets, the expanders were positioned in a partially submuscular plane.

The average operating time was 40 minutes (range 35–52 min). On average, two anterior intercostal perforators per breast were detected. In all four cases, the flap was based exclusively on the medial perforator alone. Patient discharge occurred 2 days after surgery (1–3 d). The drain was removed on the eighth postoperative day (6–12 d).

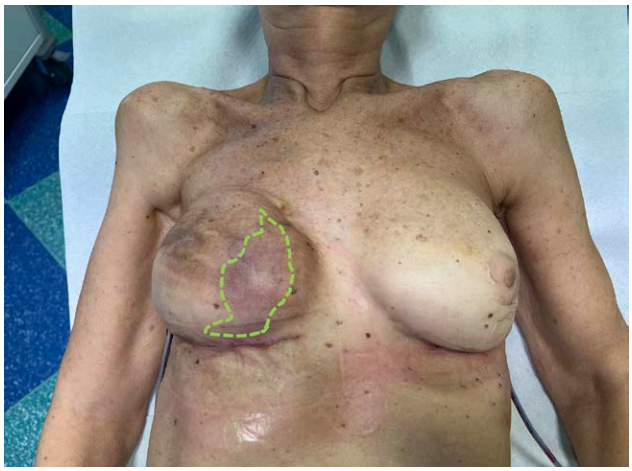

Fig. 5. Total autologous periprosthetic pocket. AICAP "shield flap" (green dashed lines) provides additional coverage to the breast implant, interposing the flap itself between the breast implant (posteriorly) and the mastectomy flap (anteriorly) in the most radio-damaged area.

In the postoperative period, no complications were detected, the Doppler evaluation reported good signal in all cases, and the wounds healed without complications. Asymmetry of the inframammary fold was reported in one case. The average follow-up duration was 6 months (2–12 mo). There were no signs of infection or implant exposure in any of the cases. No cases of implant exposure were recorded in patients who underwent the AICAP shield flap. No cases of breast expander dislocation were recorded in patients who underwent a totally autologous periprosthetic pocket with the pectoralis major muscle and AICAP flap.

Case 1

A 82-year-old patient with a history of heavy smoking was diagnosed with right breast cancer in 2003. She underwent quadrantectomy in her right breast with simultaneous right axillary lymphadenectomy, followed by adjuvant radiotherapy. In 2021, a tumoral recurrence occurred in both her breasts, leading to a proposed bilateral nipple-sparing mastectomy. Bilateral reconstruction with submuscular breast tissue expanders was planned concurrently. Following adjuvant radiotherapy, a marked area of chronic radiodermitis developed in the central and inferior parts of the breast, displaying classic signs like subcutaneous tissue thinning, dyschromia, and hair loss. No signs of inflammation or infection were noted at the time of mastectomy. In December 2022, she underwent expander-to-implant exchange (Fig. 2). In this reconstructive step, a 15×4 cm dermo-adipose AICAP flap (shield flap) was planned to cover the implant in the inferomedial part of the right breast (Fig. 3). Other possibilities such as lipofilling and autologous flaps were discussed with the patient but, following patient examination, were discarded. In fact, the patient had no donor sites for fat harvesting and presented various contraindications to free tissue transfers for her multiple comorbidities (smoking habit, heart disease, and diabetes) and advanced age. Moreover, reconstruction by means of a latissimus dorsi myocutaneous flap was unusable for the marked ipotrophy of the muscles of the back and right shoulder due to brachial plexus avulsion in infancy. The patient presented at the 10-month follow-up, healed completely (Fig. 4).

Case 2

A 72-year-old patient underwent quadrantectomy of the upper-outer quadrant of her right breast in 1991, followed by radiotherapy. For a breast cancer recurrence diagnosed in August 2023, she underwent right nipple-sparing mastectomy. At the time of reconstruction, however, there was evidence of a partial iatrogenic absence of the pectoralis major muscle in its inferolateral

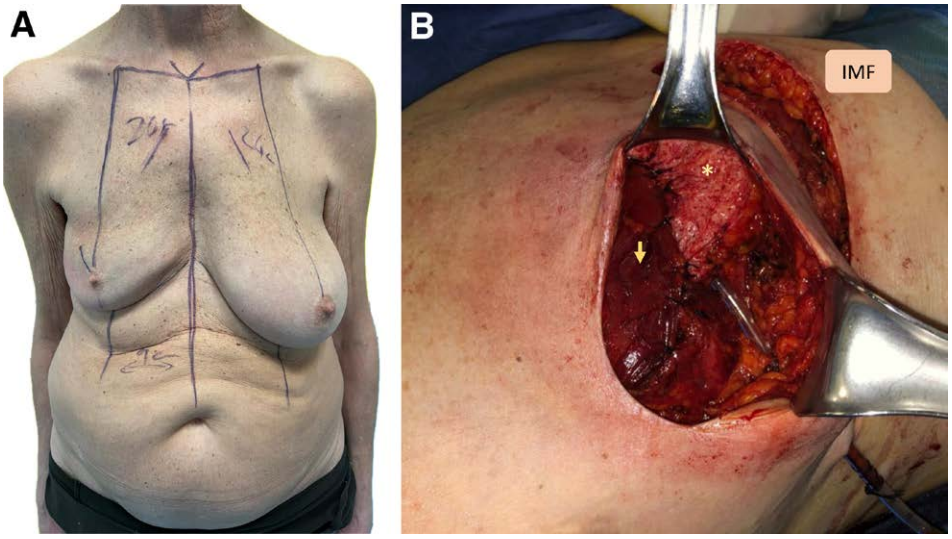

Fig. 6. Total autologous periprosthetic pocket. A, Preoperative markings. B, Intraoperative picture documenting the suture between the inferior border of the pectoralis major muscle (arrow) and the AICAP flap (asterisk) for coverage of a breast expander.

Fig. 7. Immediate postoperative result following inframammary fold reconstruction. The preexisting lateral radial incision (from previous quadrantectomy) was used to perform the mastectomy and the inframammary fold incision for flap harvesting. Blood supply to the mastectomy flaps was preserved because the distance between the two incisions was about 8 cm along the hemiclavicular line and about 13 cm laterally.

portion, likely removed at the time of quadrantectomy. This made creating a periprosthetic pocket in the inferolateral portion challenging. Therefore, an AICAP flap was planned and transposed cranially to the mammary region to facilitate the formation of a totally autologous periprosthetic pocket (pectoralis major muscle superomedially and AICAP flap infero-laterally; Figs. 6 and 7).

DISCUSSION

The use of intercostal artery-based flaps is not a new procedure because it was first described in 1931 by Esser.[11] Only recently, the perforator flap concept was applied to many donor site areas, including the anterior thoracic wall, culminating with the description of the AICAP flap in 2006.[4] Since then, the AICAP flap has been widely used for partial breast reconstruction following breast-conserving surgery,[5–8] coverage of exposed breast implants,[9] volume replacement following breast implant explantation,[12] and for the treatment of difficult epigastric abdominal wounds.[13]

The AICAP flap harvesting is a relatively simple and safe procedure, with an excellent donor site aesthetic outcome as, in fact, its harvesting does not necessitate an additional scar when the incision is positioned in the inframammary fold.

Vascular anatomy and radiological studies[2] have enabled better definition of the location of the perforators of the anterior intercostal arteries on the chest wall. These studies have revealed that the most numerous major perforators are located in the lateral third. However, despite the predominance of perforating vessels in this region, no perforator is considered "dominant," as any perforator, regardless of size or origin, can irrigate the entire flap.

Denning et al[14] demonstrated that the AICAP flap could be used to fill volumetric deficits after quadrantectomy or partial breast resection, achieving excellent aesthetic results and utilizing the same surgical incision as the demolition. In his work, Denning described the setting up of the AICAP flap similarly to what we have described, but without the association of the AICAP flap itself with prosthetic devices.

Angrigiani et al[12] described the use of the AICAP flap as a volume replacement after breast implant explantation, not in conjunction with prosthetic devices but as a replacement for them. Conversely, Mesa et al[9] in 2022, described the AICAP flap as a salvage technique after implant exposure. In this case, the AICAP flap was used to cover an exposed implant and not as a technique to prevent exposure itself, as we proposed.

Radiotherapy, commonly performed as oncological treatment for breast cancer, can result in heavily damaged skin flaps and chronic radiodermatitis. In our institution, the AICAP flap was used for the first time to prevent implant exposure in patients with heavily damaged skin flaps. The rationale for using a flap in this context was to introduce new vascularity to the area, thereby improving local tissue trophism, and to interpose a well-vascularized tissue layer between the implant and the skin flap. This function could be similarly performed by local and free flaps as well as fat grafting. To our knowledge, these are the first cases reported in the literature where AICAP flaps were used to prevent implant exposure in patients with chronic radiodermitis, covering partially the implant in the most troublesome area. We used the AICAP flap combined with a breast implant when all the other options were unavailable or unsuitable for the patient. Another novel indication introduced in this study is the inferolateral coverage of the expander pocket by the AICAP flap. The rationale here is to lower the inframammary fold without the need of elevating the rectus fascia, which may cause cranial migration of the expander. The AICAP flap offers the advantages of not sacrificing muscles during harvesting and being always available, even in very thin patients with subcutaneous hypotrophy. Its main disadvantage is the interruption of the inframammary fold, necessitating its intraoperative reconstruction, and the difficultly of postoperative monitoring due to the absence of a sentinel skin island. For the former, inframammary fold reconstruction could be advantageous in patients whose inframammary fold is located more cranially than the opposite side, as frequently seen in patients undergoing radiotherapy, and there is a need for its reposition. Such patients are optimal candidates for our reconstructive technique.

In conclusion, it is important to acknowledge the limitations of our study. Although the AICAP flap represents a promising technique for prosthetic breast reconstruction in complex clinical scenarios, the limited number of patients treated and the brevity of the follow-up period preclude definitive conclusions regarding its efficacy in preventing implant exposure. Our findings suggest potential benefits; however, a longer follow-up period and the analysis of a larger cohort of patients would provide more substantial evidence to support the reliability of the AICAP flap in such challenging cases.

CONCLUSIONS

The AICAP flap is a straightforward, safe, and aesthetically pleasing procedure that does not require additional incisions beyond the inframammary fold. Although further research is needed to solidify our findings, its novel applications show promise for broadening reconstructive options in breast surgery. Given its low donor site morbidity, the AICAP flap may become the preferred method for managing at-risk skin flaps in breast reconstruction, including prepectoral approaches.

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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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