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Evaluation of Anterior Intercostal Artery Perforator Flap for Oncoplastic Immediate Reconstruction Following Breast-Conserving Surgery in Lower Breast Quadrants Lesions; an Institutional-Based Study

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Introduction: The incorporation of oncoplastic surgery techniques in the management of breast cancer became more popular and offers both oncological safety and good cosmetic results. It is highly challenging for surgeons to obtain good oncological control and acceptable cosmetic results, especially in tumors in the lower quadrant of the breast. The utility of anterior Intercostal Artery perforator flap (AICAP) in immediate reconstruction following breast-conserving surgery (BCS) is rarely described in the literature. In our study, we present our experience with the Anterior Intercostal Artery Perforator flap in 20 patients with small to medium-sized breasts.

Patients and methods: From June 2018 to June 2021, twenty female patients underwent quadrantectomy followed by reconstruction using an AICAP flap.

Results: The surgical excision margins were negative in all patients and no re-excision was needed. The dimensions of the flap were matching the defect size or were slightly larger due to anticipation of tissue shrinkage post radiation, with a mean of 7 × 5 × 3 cm (range of 4.6–10 × 3–6× 2–5 cm). The postoperative complications were observed in only one patient (5%) in the form of mild wound infection. An average percentage of excellent to good results was obtained in 95% of cases.

Conclusion: The AICAP flap is an important addition in the field of oncoplastic immediate reconstruction after BCS, especially in patients with small to moderate breast sizes. The technique is oncologically safe and provides improved aesthetic results after quadrantectomy for tumors in the lower quadrants of the breast.

Key words: Breast-conserving surgery, Anterior Intercostal Artery Perforator Flap, Breast Cancer.

Introduction

Breast-conserving surgery (BCS) is now considered to be an established treatment of the early stages of breast malignancy, with a proven disease-free survival equivalent to that of mastectomy. The role of BCS on patients' psychological well-being and a better quality of life is obvious.[1–3] However, BCS may be associated with deformities in the form of depression or nipple-areolar complex (NAC) deviation, especially when the resulting lumpectomy defect is large in relation to small breast size or if the tumor is situated in cosmetically sensitive areas.[4]

Oncoplastic breast surgery (OBS) utilized plastic surgical procedures in the management of breast cancer. This expands the scope of BCS and avoids the associated deformities leading to improvement in the quality of life of the patients and optimal cosmesis.[5–8] Those techniques utilized the common patterns of breast reduction surgery markings to guide tumor resection, and they implied a strategic selection of local flaps for volume replacement.

In case of lumpectomies that require volume replacement involving excision of more than 20% of breast volume (As opposed to volume displacement typically achieved via dermo-glandular flaps), regional fascio-cutaneous and myo-cutaneous flaps are commonly used for autologous reconstruction, and they include latissimus dorsi (LD), medial intercostal artery perforator (MICAP), lateral intercostal artery perforator (LICAP), lateral thoracic artery perforator (LTAP), and thoracodorsal artery perforator (TDAP) flaps.[9–12]

The LICAP flap was thoroughly described by Hamdi et al.[13,14] for partial breast reconstruction following BCS. It has the advantage of being relatively easy to raise and inset. In addition, it does not harm other relevant reconstructive options (i.e., it does not sacrifice important vascular pedicles and spare the latissimus dorsi muscle that may be needed for possible future mastectomy and breast reconstruction).

The modified LICAP flap was a refinement of the original LICAP flap, and it provided a better cosmetically pleasing donor site scarring. Other refinements of this flap have been reported, such as choosing an anterior perforator rather than a lateral one, for better flap tissue mobilization and utilization.[15]

Despite favorable arguments concerning intercostal perforator flaps, the anterior ICAP flap has rarely been described in the literature, and there is a scarcity of clinical studies evaluating its efficacy.[16]

Carrasco-Lopez et al. in (2017) reported a series of 14 patients demonstrating the clinical application and the successful use of AICAP flap for

reconstruction following BCS.[17] They also performed anatomical and radiological studies on cadavers, and they described the anatomical implications of the anterior intercostal perforators span along the inframammary fold from the xiphoid process to the anterior axillary line.[18]

In our study, we present our initial experience with the anterior ICAP flap for oncoplastic reconstruction after BCS comprising quadrantectomy for tumors in the lower breast quadrants in small to medium-sized breasts, demonstrating its oncological safety and aesthetic outcomes.

Patients and methods

From June 2018 to June 2021, twenty female patients diagnosed with breast cancer in the lower quadrants of the breast were prospectively recruited to perform BCS in the form of quadrantectomy with immediate reconstruction using an anterior ICAP flap. The study was conducted in the Department of General Surgery, Faculty of Medicine, Ain-shams University. The study design was approved by the Research Ethical Committee (REC) of the Department of Surgery, An Shams University and an informed written consent was signed out by all participants in the study after discussion and education about the technique.

All the patients were subjected to full history taking, clinical breast and axillary examination, and bilateral sono-mammography. A tru-cut needle was obtained from the affected lesion and confirmed its malignant nature. Inclusion criteria included patients with small breast sizes (Small C cup or smaller) not suitable for oncoplastic breast reduction and lumpectomy excision volumes of up to 1/3rd of the breast volume. Stages of the tumor included were T1 and T2 tumors with neoadjuvant chemotherapy and preoperative wire localization if indicated. Exclusion criteria included patients with T3 and T4 tumors, multi-centric tumors, inflammatory breast tumors, and patients with diffuse micro-calcifications or patients with distant metastasis. Lesions within 1 cm from the nipple-areolar complex (NAC) were also excluded.

Surgical technique

All the patients included in the study were preoperatively reviewed in the breast surgery unit by our multidisciplinary team (MDT), the decision of performing the procedure was taken and the resection plan and markings were done. The markings were done while the patient was in the upright position (standing or sitting) to allow accurate evaluation of the anatomical landmarks. Firstly, the inframammary fold was marked delineating the upper border of the flap, then the flap width was estimated through the amount of inframammary skin and fat by pinch test delineating the lower border of the flap. The two lines were tapered to meet together medially on the IMF near the xiphoid process and laterally at the anterior axillary line creating a crescent-shaped flap. This design helps to prevent the dog's ear deformity at closure. **(Figures 1 a,b).**

The hand-held doppler ultrasound was used to confirm the location of appropriate perforators and marked on the skin with the patient in the supine position

On the same day of surgery, different variables including breast size, tumor size, location, and the estimated defect values were revised. On the operating table, the proposed perforators were located using hand-held doppler ultrasound and markings were repeated. The flap was designed

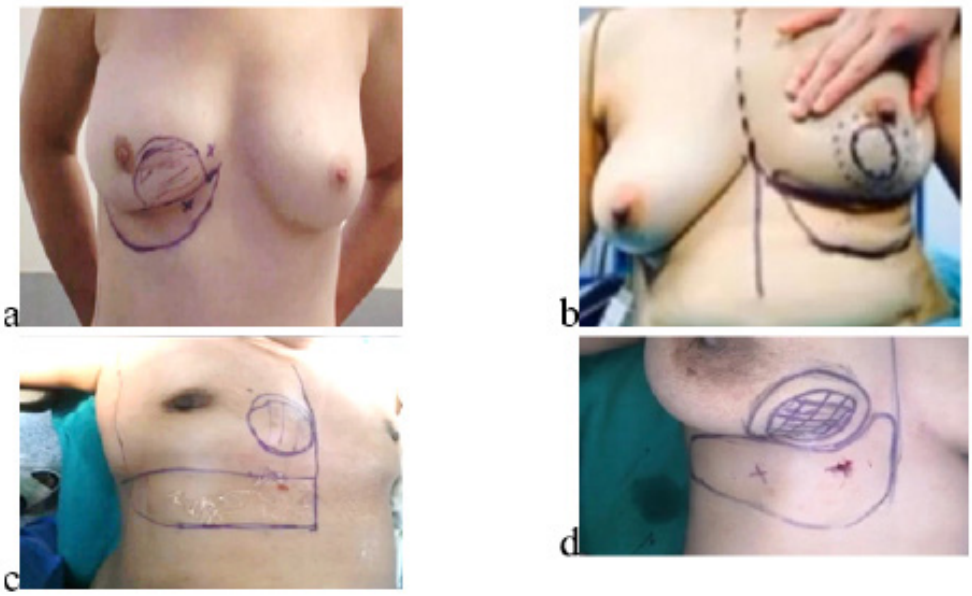


Fig 1: Preoperative marking (Flap design and mapping of the perforators).

with the patient positioned for surgery (in the supine position, with the arm abducted at 90 degrees for lymph node surgery (Dissection and/or sentinel node biopsy [SNB]). **(Figure 1 c,d).**

It is important to state that we always used the closest perforator to the expected defect. Using the closest and careful dissection of the perforator allowed the introduction of the whole flap into the breast. Based on that fact, if the expected defect was in the lateral quadrants, we searched perforators in the lateral part of the flap, and if the defect was in the internal quadrant, we searched perforators in the medial part of the flap.

Operative technique

After induction of general endotracheal anesthesia and muscle relaxation. The operation was done in three stages as follows:

The first stage was axillary surgery: Axillary surgery was done through an axillary incision. The incision was deepened down till reaching the clavi-pectoral fascia, which was exposed and opened to enter the axillary space. Sentinel lymph node biopsy or axillary dissection was done according to the preoperative decision for each patient. In the case of a positive sentinel lymph node biopsy, axillary dissection was performed. Special attention was taken not to harm the thoracodorsal pedicle which should be spared if future reconstruction using an LD flap was needed. A single drain was left in the axilla if axillary dissection was performed.

The second stage was tumor resection: The standard quadrantectomy technique for tumor resection was done using an inframammary fold incision (Corresponding to the upper border of the flap) **(Figure 2)** The upper breast skin flap was created, and dissection continued overlying the whole tumor and the surrounding safety margin, the tumor was then, excised down to the pectoral fascia with at least a 1-cm safety margin from all directions. The tumor bed was marked by clips. The margins of the specimen were marked by threads and sent to the frozen section for histopathological examination for radial marginal assessment. In the case of certain margin infiltration, a wider re-excision would be performed. If the tumor was in close proximity to the skin, it would be removed together with the tumor.

The third stage is flap harvesting and reconstruction: After resection, the location of the perforators was confirmed by searching the same resection incision. Normally, we dissected at least two of them. The lower border of the flap determined by pinch test was incised and flap elevation proceeded from distal to proximal to the supra-fascial perforator. An important note is that we incorporated "beveled out "as much subcutaneous fat as possible from the inferior aspect to maximize the volume of tissue used in reconstruction **(Figure 3).** The perforators were located, dissected carefully, and assessed manually by two fingers for pulsation. We dissected and preserved at least, two of them which is considered a very crucial point. We chose the closest perforators to the defect. The perforator was well-dissected to facilitate placement of the whole flap inside the breast without any tension or twisting of the pedicle. No aggressive isolation or dissection of the perforators is needed if the flap attains sufficient mobility **(Figure 4).** Other perforators were sometimes, sacrificed, especially if they were not related to the defect. De-epithelization of the skin overlying the harvested flap was done and its vascularity was insured **(Figure 5).** If the skin overlying was removed with the tumor, then a skin paddle would be marked and designed to match the defect size and the remaining flap would be de-epithelized. The whole flap was introduced into the breast defect and its edge was fixed to the pectoral fascia with 2/0 Vicryl sutures. A single surgical drain was typically left in the breast region (Not in the flap donor site). The inframammary fold was marked, and the lower edge of the incision was elevated and fixed to the chest wall with interrupted 2/0 PDS sutures to avoid scar migration downwards and distortion **(Figure 6)**. The incision was closed in a layered fashion **(Figures 7,8).**

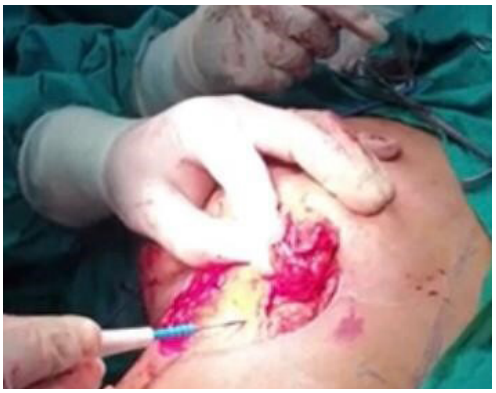


Fig 2: Excision of the tumor (Quadrantectomy).

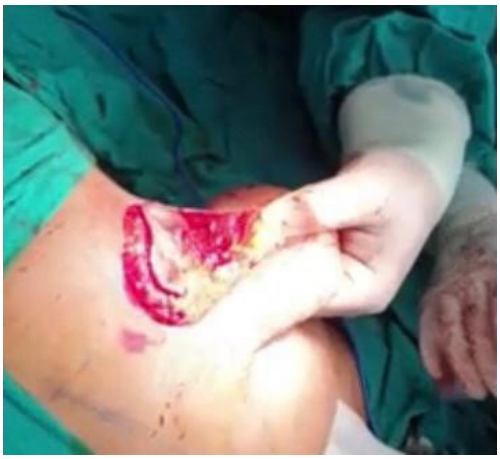


Fig 3: Harvested fap with surrounding "Beveled fat".

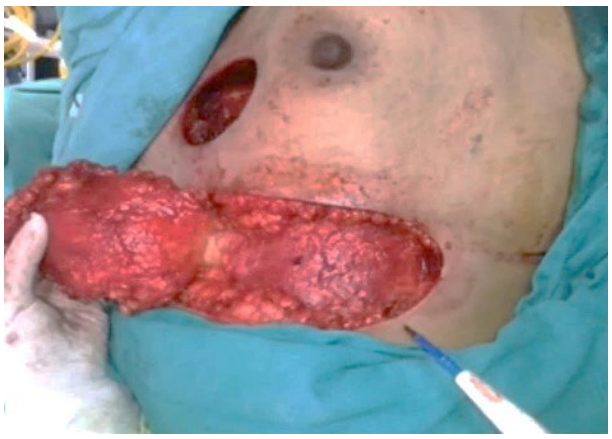


Fig 4: Mobilized flap around its vascular pedicle.

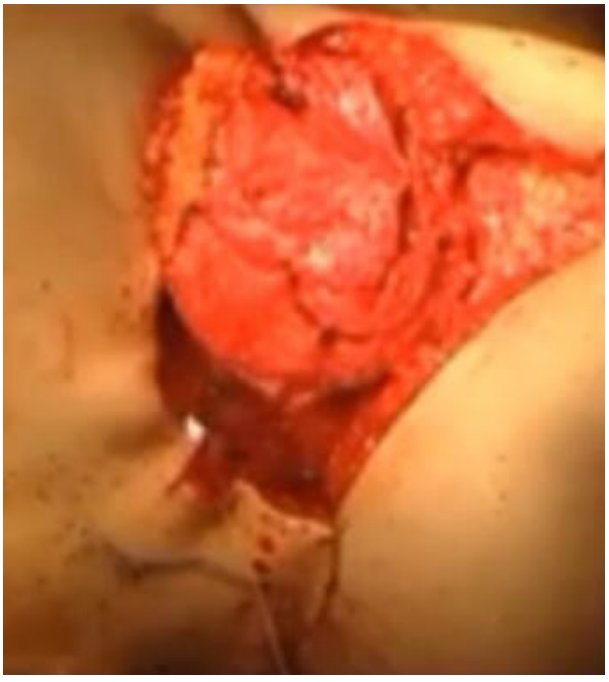


Fig 5: Appearance of the flap after overlying skin de-epithelization.

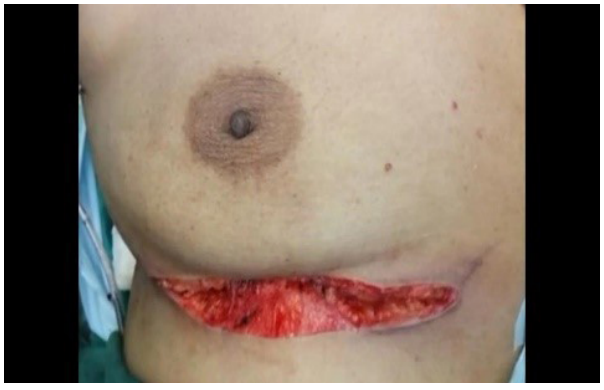
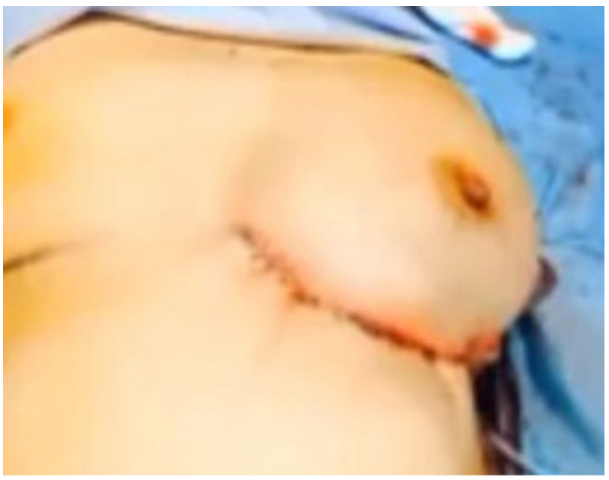


Fig 6: Fixing the flap to the inframammary fold.



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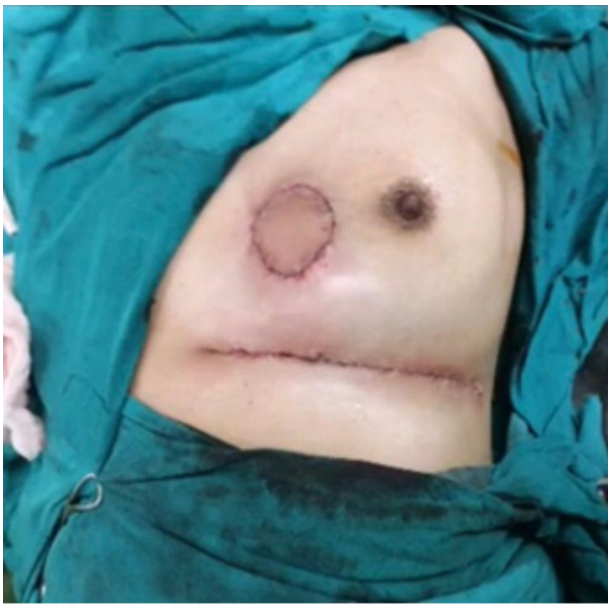

b

Fig 7: Immediate postoperative photos.

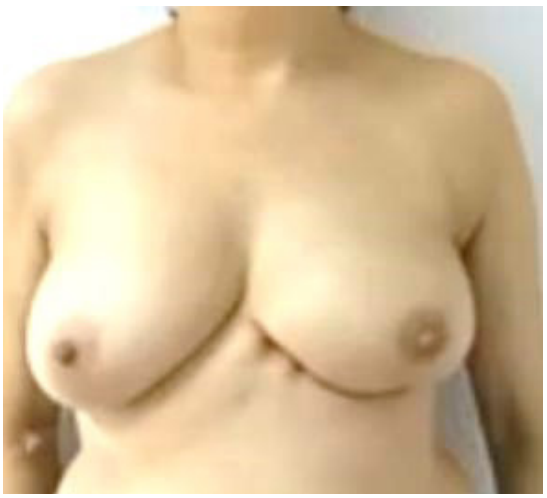

Fig 8: One day postoperative.

The operative data including positive margins and need for re-excision, the weight of the specimen, type of axillary surgery, length of the flap, type of perforators used, and the operative time were recorded and assessed.

All the patients were discharged on the first postoperative day with a drain in place. The drains were removed when discharging less than 50 cc/24 hours. Patients were reviewed in the outpatient clinic after one week and two weeks for assessment of the presence of postoperative complications and to plan the adjuvant therapy. **(Figure 9).**

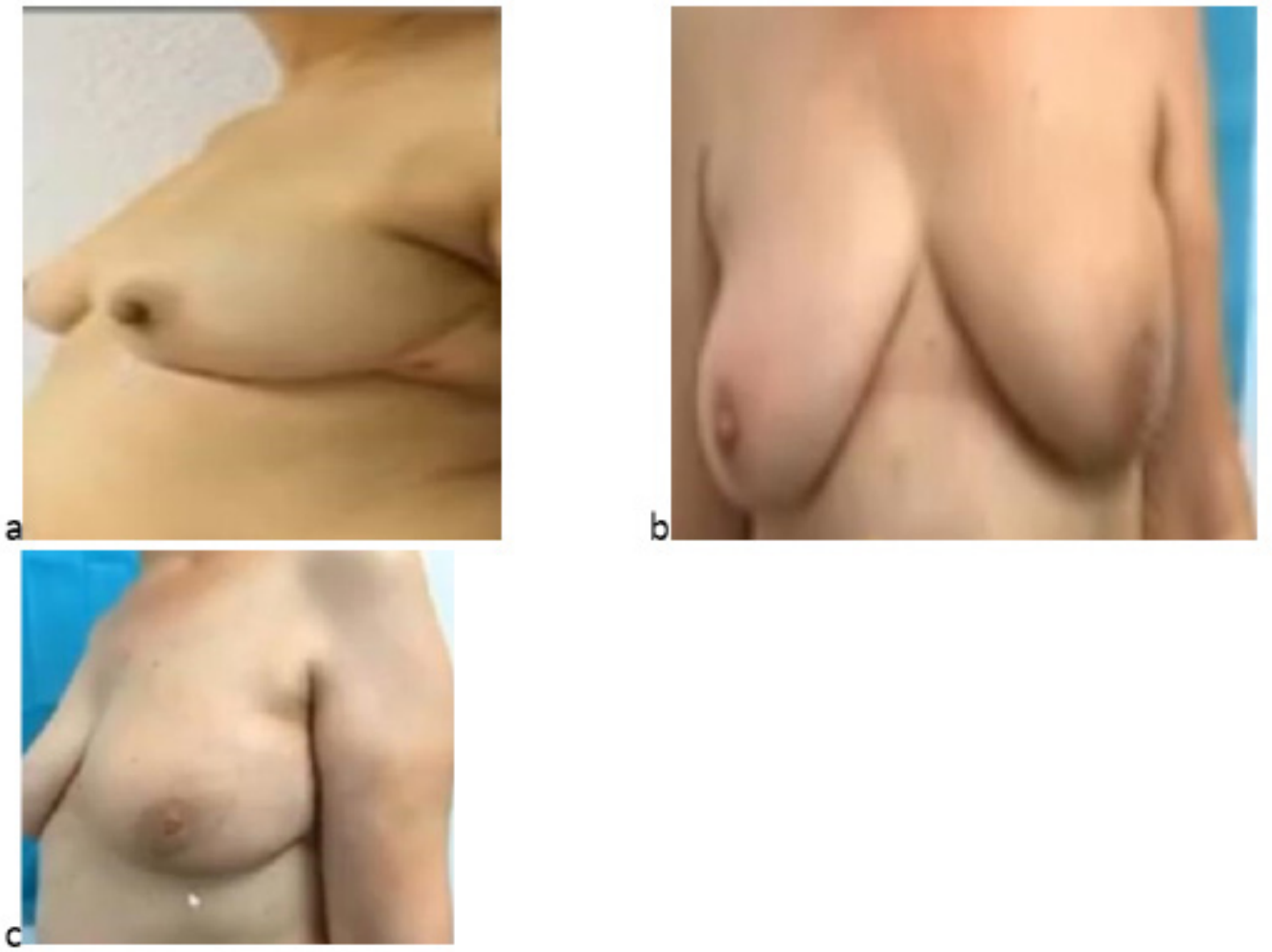

Fig 9: Post-operative results after 1 month.

The follow-up schedule for all patients was reviewing the patient through our multidisciplinary team every four months for the first 3 years and every six months for the next two years. Bilateral sono-mammography was requested every year.

The cosmetic outcome was assessed by asking the patient herself to rate the result of surgery as regards breast symmetry, scarring, and degree of satisfaction using the Harvard 4-point scale (Excellent, good, fair, or poor). The objective assessment was done by two specialized breast surgeons not participating in the study and also rated on a 4-point scale (Excellent, good, fair, or poor). The surgeon's evaluation was based on five criteria (Breast symmetry, breast tissue defects, position and deformity in NAC, scarring, and retraction).

Statistical analysis

was done by the IBM SPSS Statistics for Windows, Version 28.0. Armonk, NY: IBM Corp. Quantitative data were expressed as mean and standard deviation. Qualitative data were expressed in frequencies and percentages.

Results

In our prospective study, twenty female patients diagnosed with invasive breast cancer in the lower breast quadrants were subjected to quadrantectomy followed by reconstruction using an AICAP flap. The mean age of the patients was 38.6 ± 7.38 (32 - 45) and their mean body mass index (BMI) was 25.5 kg/m2 (20.9 –28.8) kg/m2. Eleven patients had breast cup size B, and nine patients had breast

cup size C. Most of the patients were medically free (90%), one patient was diabetic (Type I DM), and one patient was hypertensive. Most of the tumors were in the lower outer quadrant in 13 patients (65%). The mean size of the tumors (SD) was 1.9 ± 1 and ranges between (1.5 – 3.6) cm. According to the TNM classification, T1 tumors were found in 11 cases and T2 tumors in 9 cases. Two patients had clinically palpable axillary lymph nodes and eleven cases had radiologically pathological lymph nodes. The majority of the patients had invasive ductal carcinoma (85%) and three cases had invasive lobular carcinoma. Two patients received neoadjuvant chemotherapy. Lumpectomy volume was one-third of the breast in nine patients and one-fourth of the breast in eleven patients **(Table 1)**. The flap design was planned according to the size and location of the defect at the time of surgery. The dimensions of the flap were matching the defect size or were slightly larger because of anticipation of tissue shrinkage post radiation, with a mean of 7 × 5 × 3 cm (Range of 4.6–10 × 3–6× 2–5 cm)

The mean operative time of the procedure was 130 minutes and ranged between (122 -148) minutes and the mean reconstruction time was 35 minutes and ranged between (22 – 40) minutes. The surgical margins were free in all cases and no cases required re-excision. In one case the tumor was superficial, and the overlying skin was excised with the tumor and a skin paddle was designed on the flap surface to match the defect. The mean weight of the excised specimen was 65 gm and ranged between 42 to 87 gm. Sentinel lymph node biopsy (SLNB) was proved negative in five cases and level I and II axillary dissections was completed in the rest of the patients. No contralateral symmetrization was needed in any of the patients **(Table 2).**

The mean period of follow-up was 14 months and ranged between 12 to 18 months. No significant complications were encountered in the postoperative period apart from one case of wound infection which was managed conservatively by oral antibiotics. No marginal skin or flap necrosis occurred in any of our patients. All the patients received their adjuvant therapy according to our institutional protocols **(Table 3).**

A single patient developed loco-regional recurrence in the ipsilateral breast in the upper outer quadrant at 12 months of follow-up and was managed with salvage mastectomy. None of the patients developed distant metastasis during the follow-up course of the study.

Concerning the cosmetic outcomes, the results assessed by the patients were excellent in 18 patients, good in 1 patient, fair in 1 patient, and no poor results. The results assessed by the surgeons were excellent in 17 patients, good in two patients, fair in one patient, and no poor results.

The average percentage of excellent results was 87.5%, good in 7.5%, and fair in 5% of cases. No poor results. Final outcomes were satisfactory with none of the patients complaining about the hard consistency of the reconstructed breast and high satisfaction was obtained in all patients at their last follow-up visit **(Table 4).**

Table 1: Patients' demographic data and tumor characteristics

Age mean ± SD (range) years			38.6 ± 7.38 (32 - 45)
Body mass index mean ± SD (range) kg/m²			25.5 ± 3.1 (20.9 –28.8)
Comorbidities n (%)		Diabetes mellitus	1 (5)
		Hypertension	1 (5)
		No	18 (90)
Breast cup size		B	11 (55)
		C	9 (45)
Breast lumpectomy volume		1/3 of the breast volume	9 (45)
		1/4 of the breast volume	11 (55)
Defect dimensions mean ± SD (Range) in cm		Length	6 ± 1.4 (3.5 – 8)
		Height	3.7 ± 0.4 (3.0 – 6)
		Thickness	3.2 ± 0.3 (4– 8)
Tumor location (n)(%)		Lower outer	13 (65)
		Lower inner	4 (20)
		Lower central	3 (15)
Tumor size mean ± SD (range)cm			1.9 ± 1 (1.5 – 3.6)
Pathological tumor type (n)(%)		Invasive ductal carcinoma	17 (85)
		Invasive lobular carcinoma	3 (15)
TNM classification (n)(%)	T	1	11 (55)
		2	9 (45)
	N	0	9 (45)
		1	11 (55)
		2	0 (0)
	M	0	20 (100)
		1	0 (0)
Neoadjuvant chemotherapy (n) (%)			2 (10)

Table 2: Operative findings and postoperative sequelae

Operative time mean ± (Range) min		130 ± 5.2 (122 -148)
Reconstruction time mean ± (Range) min		35 ± 4.5 (22 – 45)
Intraoperative margins assessment n(%)	Positive	0 (0)
	Negative	20 (100)
Weight of excised specimen (SD) (Range)gm		65 ± 5.2 (42 -87)
Axillary surgery n(%)	Sentinel lymph node biopsy	5 (25)
	Axillary dissection (levels I and II)	15 (75)
Flap size mean ± (Range) cm	Length	7 ± 1.6 (4.6 – 10)
	Width	5 ± 1.1 (3 – 7)
	Thickness	3 ± 0.7 (2 – 5)
Skin paddle needed n(%)		1 (5)

Table 3: Postoperative complications

Postoperative complications	n (%)
Wound infection	1 (5)
Hematoma	0 (0)
Seroma	0 (0)
Marginal skin necrosis	0 (0)
Flap necrosis	0 (0)
Asymmetry	0 (0)
Fat necrosis	0 (0)
Local recurrence	1 (5)
Distant metastasis	0 (0)

Table 4: Assessment of cosmetic outcomes

Cosmetic outcome (n)(%)	Patients	Surgeons	Average percentage
Excellent	18 (90)	17 (85)	87.5%
Good	1 (5)	2 (10)	7.5%
Fair	1 (5)	1 (5)	5%
Poor	0 (0)	0 (0)	0%

Discussion

The safety of breast-conserving therapy comprising wide local excision and radiotherapy in the early stages of breast malignancy has been proved. The disease-free survival rates are not different from that of mastectomy.[4]

Breast conservative surgery (BCS), comprising wide local excision of tumors, may result in undesirable breast asymmetry and deformities resulting from skin and parenchymal retraction which leads to volumetric changes in the breast. In addition, when postoperative radiotherapy is implemented, more adverse outcomes on healthy breast tissues appear. These adverse outcomes may include increased pigmentation, telangiectasia, and more skin retraction and fibrosis resulting in more deformities.[8]

The immediate reconstruction of breast defects following BCS is highly adventitious. Firstly, it allows better restoration of the breast mold which is difficult to be achieved when the reconstruction is delayed following radiotherapy. Secondly, it provides a safely wider marginal tumor excision and decreased the rates of re-excision.[19]

The oncoplastic procedures for immediate reconstruction after BCS may be divided into two categories. Firstly, the volume displacement procedures include reduction mammoplasty techniques or redistribution of the breast parenchyma using dermoglandular advancement flaps. The second category is the volume replacement procedures using autologous local or distant flaps and/or prosthetic implants.[19]

The utility of intercostal perforator flaps was introduced as volume replacement flaps for oncoplastic immediate reconstruction of breast defects following BCS. These flaps can be used either as pedicled flaps,[20–22] or as free flaps.[23]

Despite its usefulness as an oncoplastic reconstructive option following BCS, the AICAP flap is rarely described in the literature, apart from a few case reports.[13,23,24] It is particularly useful in patients with small-sized breasts in whom reduction mammoplasty is considered inappropriate. The AICAP flaps had several advantages, being reliable, easy to learn, and not needing advanced microsurgical knowledge. It does not require dissection of the perforator down to its origin to gain enough mobility of the flap due to its proximity from the breast in comparison with lateral ICAP flaps which are situated more distally and require deeper dissection to gain enough mobility of the flap.

The anterior ICAP flaps are highly versatile, they can be designed to be used in each breast quadrant. After flap harvesting, it can be folded, advanced, or rotated in most breast quadrants. In cases of more distally located breast defects, it can even be used as a supportive adjunct to volume displacement dermo-glandular flaps.

In our study, we included patients with tumors situated in the lower breast quadrants which are

considered difficult and challenging reconstructive areas. Our findings agree with the study by Denning et al. in 2020, they performed the AICAP flap for tumors in the inferior pole of the breast.[21] On the other hand, some authors reported the use of the AICAP flap for tumors in the lateral, superolateral, central, and lower inner quadrants.[17]

The mean age of the study group was 38.6 years and ranged between (32 – 45 years). This age was relatively younger than expected. This may reflect increased community awareness and governmental initiatives for women's health and screening for early breast cancer.

Most patients included in our study were thin, and their mean BMI was 25.5 kg/m2 and ranged between (20.9 –28.8 kg/m2) with small to medium breast cup size (B or C). The procedure is a suitable option for such a group of patients as proposed by many other studies.[13,16–18,20–22] Historically, mastectomy was indicated in such cases because quadrantectomy was not applicable.[25]

The blood supply of the AICAP flap is reliable and the flap is designed about 3 cm below the IMF.[26] The size of the flap could be variably designed along an inframammary fold (Normally, 15–20 cm in length) and the width of the flap is determined by the pinch test (Normally, 4–7 cm wide). Although the width of the flap is nearly constant, it should be noted that peripheral "beveling out" to incorporate more fat is recommended.[21]

In our study, the preoperative mapping of the perforators was beneficial using the hand-held Doppler ultrasound for its high sensitivity and specificity in the AICAP flap as proposed by various studies.[13,16–18,20–22] Some authors advocated the use of CT angiography, however, it was not routinely used because of the nearly constant anatomical locations of the perforators, as well as the unwarranted radiation involved in this imaging modality.[18]

In addition, the AICAP can also provide a good skin paddle if a part of the skin is removed. Therefore, AICAP is a good reconstructive technique for quadrantectomy resections in small to medium-sized breasts with a 25%–30% breast tissue defect after resection.[18,27]

The accurate preoperative planning and estimation of the defect size matching with the flap design were crucial for the success of the procedure. Although perforators were found along the entire length of the flap as evidenced by anatomical studies,[17] the choice of the closest perforators to the location of the defect facilitates changes to the pivot point being near the resection place and allows for a better arc of rotation of the flap. The good dissection of the perforators allows for the whole flap insertion into the breast without pedicle tension and prevents modifications in the IMF.

The quadrantectomy resections allowed wider margins of excision and decreased the rates of re-excision and positive margins in frozen section assessment, especially when the reconstructive option is available.[28] All the patients in our study had free surgical margins upon excision. Only one patient developed wound infection postoperatively. The infection was mild and was managed conservatively with oral antibiotics without delay in receiving adjuvant therapy and radiotherapy. Only one patient in our study developed local recurrence at 12 months of follow-up. This highlights the feasibility and oncological safety of the procedure.

Concerning the cosmetic outcomes, we had no poor outcome results. The donor site of the AICAP flap is well hidden within the IMF and offers a better cosmetic outcome than most other reconstructive procedures including the lateral perforator flap (LICAP) procedure. AICAP restores the original breast mold and contour, and no breast symmetry procedures are needed in the contralateral breast. No significant changes were reported to the flap following radiotherapy apart from skin changes that were similar to that of the irradiated breast.

The main disadvantage of this flap is the lack of breast tissue consistency, which may be harder than normal breast tissue. Despite this, none of our patients complained about breast firmness.

The main strength of our study is that despite the limited data about the use of AICAP flap in breast reconstruction following BCS, the study is among the first prospective studies to explain the role of AICAP flap in breast reconstruction in a series of breast cancer patients in Egypt. In addition, the relatively long follow-up period (Mean follow-up of 14 months) was important to assess the long-term outcomes. The main limitation of the study is the absence of randomization and the control group. We believe that the AICAP flap is underestimated as an oncoplastic reconstructive option following BCS, and we feel it deserves greater prospective studies for better evaluation of the outcomes and improvements in the technique.

Conclusion

The AICAP flap as an oncoplastic immediate breast reconstructive option is oncologically safe, reliable, fast, and associated with low morbidity and good aesthetic outcomes. It acts as a simple and effective reconstructive choice in BCS patients with small to medium-sized breasts for lower pole breast tumors.

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