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Efficacy of autologous fat grafting for breast reconstruction after partial mastectomy in Iraqi women with breast cancer: A prospective clinical study

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Abstract
Blast injuries remain a major cause of complex upper extremity soft tissue defects in Iraq, often threatening limb viability and function. At Ghazi Al-Hariri Hospital for Surgical Specialties the leading tertiary trauma and reconstructive center in Baghdad local flaps have been systematically used as a practical, cost-effective solution in a resource-limited setting with high patient volume and no microsurgical capacity.

This retrospective study (January 2017-December 2023) included 112 consecutive patients who underwent upper limb reconstruction with local flaps after blast trauma. Most were young male civilians (mean age: 27.6 years; 92% male), with improvised explosive devices (IEDs) causing 69.6% of injuries. Defects most commonly involved the dorsum of the hand (33%) and forearm (28%), and 92% exposed critical structures (tendon or bone).

Eight local flap techniques were applied based on a standardized, anatomy-driven institutional algorithm. Flap survival was 91.1% (102/112), with partial necrosis in 6.3% and total loss in 2.7%. Functional outcomes improved significantly: mean DASH scores decreased from 28.4 at 3 months to 19.1 at 6 months postoperatively, and 67.9% of patients resumed work or daily activities within six months.

Compared to free tissue transfer, local flaps reduced operative time by 74%, per-case costs by 85%, and eliminated the need for ICU admission in most cases. This single-center Iraqi experience demonstrates that local flaps provide reliable, functional, and durable limb salvage after blast injury. The findings support integrating structured, anatomy-based local flap protocols into national trauma reconstruction guidelines in conflict-affected and resource-constrained settings.

Keywords: Autologous fat grafting, breast reconstruction, partial mastectomy, breast cancer, Iraq, middle east, BREAST-Q, fat retention, coleman technique, oncological safety, adipose-derived stem cells

Introduction

1.1. The Burden of Breast Cancer in Iraq

Iraq continues to face a growing burden of breast cancer, with most women diagnosed in their 40s-50s and a high proportion treated by breast-conserving surgery (BCS). Beyond survival, Iraqi patients consistently report needs related to body image, femininity, and return to social roles. These cultural and psychosocial priorities make aesthetic restoration after BCS more than a cosmetic add-on; it is integral to comprehensive, patient-centred cancer care in resource-limited settings.

1.2. The Imperative for Aesthetic Reconstruction after Breast-Conserving Surgery

Historically, mastectomy or implant-based reconstruction dominated postoperative choices, yet both may be culturally less acceptable and clinically suboptimal in irradiated breasts. Autologous fat grafting (AFG) offers a minimally invasive, staged option that restores contour and improves skin quality while aligning with patient preferences for natural feel and appearance. Accordingly, this study evaluates AFG after partial mastectomy as a pragmatic solution that addresses both form and function without adding oncologic risk.

1.3. Autologous Fat Grafting: Scientific Rationale and Global Adoption

Autologous fat grafting (AFG) represents a paradigm shift in reconstructive surgery. Unlike implants which carry risks of rupture, capsular contracture, and foreign body reaction AFG utilizes the patient's

own tissue, offering biocompatibility, natural texture, and dynamic integration with host parenchyma [13]. The technique, refined by Coleman in the 1990s, involves harvesting adipose tissue via low-trauma liposuction, purifying it through centrifugation, and reinjecting it in micro-aliquots to maximize graft survival [14].

Beyond volume restoration, emerging evidence suggests that the stromal vascular fraction (SVF) within grafted fat rich in mesenchymal stem cells, growth factors, and anti-inflammatory cytokines may promote tissue regeneration, reduce fibrosis, and improve skin quality [15, 16]. This "regenerative" dimension has sparked interest in AFG not only for aesthetics but also for wound healing and radiation damage mitigation.

Globally, AFG is now endorsed by major plastic surgery societies for post-lumpectomy reconstruction. Systematic reviews report retention rates of 55-80% at 1 year, with high patient satisfaction and low complication profiles [17, 18]. Radiological safety has also been affirmed: while benign calcifications and oil cysts may occur, they rarely mimic malignancy or interfere with surveillance when interpreted by experienced breast radiologists [19].

1.4. The Knowledge Gap: AFG in the Middle East and Iraq

Despite its global success, AFG remains underutilized and understudied in the Arab world. Cultural preferences for "natural" reconstruction, religious considerations regarding body modification, and limited access to advanced liposuction/processing technologies have slowed adoption [20]. In Iraq specifically, no published clinical trials or case series have evaluated AFG outcomes in breast cancer patients a critical gap given the country's unique demographic, genetic, and environmental profile.

Iraqi women often have denser breast tissue, higher parity, and later age at first childbirth factors that may influence graft survival and radiological interpretation [21]. Moreover, post-war economic constraints limit access to imported implants or complex flap surgeries, making AFG which requires only basic liposuction equipment and local anesthesia an ideal, cost-effective solution.

1.5. Study Rationale and Objectives

This study, conducted at Ghazi Al-Hariri Hospital for Surgical Specialties a tertiary referral center in Baghdad Medical City represents the first prospective evaluation of AFG for partial breast reconstruction in Iraqi women. We hypothesized that AFG would yield:

- High fat retention rates comparable to global benchmarks
- Significant improvements in patient-reported satisfaction and psychosocial well-being
- Low rates of complications and radiological interference
- No compromise in oncological safety

By generating Iraq-specific evidence, this research aims to inform national clinical guidelines, empower Iraqi surgeons with validated techniques, and ultimately improve the quality of life for thousands of breast cancer survivors navigating the intersection of disease, identity, and culture.

2. Materials and Methods

2.1. Study Design and Ethical Compliance

This was a prospective, single-arm, single-center cohort study conducted at the Department of Plastic and Reconstructive Surgery, Ghazi Al-Hariri Hospital for Surgical Specialties, Baghdad Medical City, Iraq, between January 2022 and December 2023. The study protocol was reviewed and approved by the Institutional Review Board (IRB) of Baghdad Medical City (Approval No: GHSS-IRB-2021-017) and registered retrospectively in the Pan-African Clinical Trials Registry (PACTR202403789543210) to ensure transparency and adherence to CONSORT guidelines for observational studies.

All participants provided written informed consent after receiving detailed verbal and written explanations regarding the surgical procedure, potential risks (including fat necrosis, calcifications, asymmetry), benefits, alternative reconstructive options (e.g., implants, local flaps), and the voluntary nature of participation. Patients were informed that refusal to participate would not affect their oncological or surgical care.

2.2. Patient Selection and Eligibility Criteria

Inclusion Criteria

- Iraqi women aged 25-65 years diagnosed with unilateral, histologically confirmed Stage I-II invasive ductal carcinoma (IDC) or ductal carcinoma in situ (DCIS).
- Underwent partial mastectomy (lumpectomy/quadrantectomy) with clear oncological margins (≥2 mm), confirmed by intraoperative frozen section and final pathology.
- Completed adjuvant radiotherapy (standard 50 Gy in 25 fractions + boost if indicated) at least 6 months prior to AFG to minimize radiation-induced fibrosis and optimize graft survival.
- Demonstrated stable body weight (±5% fluctuation over preceding 6 months) to ensure predictable donor site availability and metabolic stability.
- Expressed dissatisfaction with post-lumpectomy breast contour confirmed via preoperative BREAST-Q screening.
- No prior breast reconstruction or augmentation.

Exclusion Criteria

- Active local or systemic infection.
- Uncontrolled diabetes mellitus (HbA1c >8.0%).
- Body Mass Index (BMI) <18 or >35 kg/m² to avoid undernutrition-related poor graft survival or donor site complications in morbid obesity.
- Pregnancy or lactation.
- History of autoimmune disease (e.g., lupus, scleroderma) or coagulopathy.
- Evidence of local recurrence or metastatic disease at time of AFG.
- Inability to comply with 12-month follow-up schedule.

Rationale for Radiotherapy Waiting Period: A 6-month interval post-radiotherapy was mandated to allow resolution of acute radiation dermatitis and tissue edema, which are known to impair fat graft vascularization and increase necrosis risk [1].

2.3. Preoperative Assessment and Planning

All patients underwent comprehensive preoperative evaluation:

- Clinical breast examination by the plastic surgeon and oncologic breast surgeon to assess defect size, skin quality, scar mobility, and symmetry.
- 3D stereophotogrammetry using the Vectra® H2 system (Canfield Scientific, USA) to capture baseline breast volume, contour, and asymmetry index. Scans were performed in standardized upright position with arms at sides.
- Mammography and breast ultrasound to confirm absence of residual/recurrent malignancy and establish baseline imaging for postoperative comparison.
- Laboratory workup: CBC, coagulation profile, fasting glucose, HbA1c, liver and renal function tests.
- Psychosocial screening: BREAST-Q "Satisfaction with Breasts" and "Psychosocial Well-being" modules administered preoperatively.

2.4. Surgical Technique: Step-by-Step Protocol

Step 1: Fat Harvesting

- **Donor Site Selection:** Abdomen (suprapubic and periumbilical regions) or medial thighs chosen based on patient preference, skin laxity, and volume requirements.
- **Tumescent Infiltration:** 500 mL of tumescent solution (normal saline 500 mL + 1% lidocaine 20 mL + epinephrine 1:1000, 1 mL) infiltrated slowly over 10-15 minutes to minimize bleeding and trauma.
- **Liposuction:** Performed under local anesthesia with sedation (midazolam 0.05 mg/kg IV) or general anesthesia (if combined with other procedures). A 3-mm blunt-tip, multiport cannula (Marina Medical, Italy) connected to 10-mL Luer-Lok syringes was used. Negative pressure was manually controlled by the surgeon (Coleman technique) to avoid adipocyte rupture.

Step 2: Fat Processing

Centrifugation: Harvested lipoaspirate transferred to sterile 10-mL syringes and centrifuged at 3000 rpm (≈1200 × g) for 3 minutes (Hettich Rotina 380R, Germany).

Fractionation: After centrifugation, three layers formed:

- **Upper:** Oil and free lipid debris (discarded)
- **Middle:** Purified adipocytes (retained for grafting)
- **Lower:** Blood, tumescent fluid, and cell debris (discarded)
- **Washing (Optional):** In cases of bloody aspirate, the middle layer was gently rinsed with lactated Ringer's solution and recentrifuged.

Step 3: Fat Injection

- **Cannula:** 16G blunt-tip infiltration cannula (Dermis Medical, South Korea) with multiple side ports.
- **Injection Planes:** Fat injected in microdroplets (0.1-0.3 mL per pass) across multiple tissue planes:
  Subcutaneous (for superficial contouring) Subglandular (to fill parenchymal defects) Intraparenchymal (to blend with residual breast tissue) Submuscular (if pectoral contouring needed)
- Technique: "Fanning" and "tunneling" methods employed to maximize surface area for neovascularization. No more than 100 mL total volume injected per breast to avoid central necrosis.
- Volume Estimation: Injected volume recorded per syringe; total volume documented in operative notes.

Figure: Schematic illustration of fat harvesting, processing, and multilayer injection technique (to be inserted as Figure 1)

2.5. Postoperative Management and Follow-Up Protocol

- **Immediate Post-op:** Light compressive dressing applied to breast and donor sites. Patients discharged same day or next morning.
- **Garments:** Elastic compression garment worn over donor sites for 2 weeks to minimize edema and contour irregularities.
- **Activity Restrictions:** No heavy lifting (>5 kg) or strenuous exercise for 4 weeks. Gentle breast massage discouraged for first 6 weeks to avoid graft displacement.
- **Medications:** Prophylactic oral antibiotics (cefalexin 500 mg QID × 5 days), analgesics (paracetamol 1g PRN), and low-molecular-weight heparin (enoxaparin 40 mg SC OD × 7 days) for thromboprophylaxis in high-BMI patients.
- **Follow-Up Schedule:** Week 1: Wound check, drain removal (if any), early complication screening
  Month 3: Clinical exam, BREAST-Q, ultrasound
  Month 6: Clinical exam, mammogram, BREAST-Q
  Month 12: Final clinical exam, 3D scan, BREAST-Q, mammogram/ultrasound, oncologic review

2.6. Outcome Measures and Definitions

Primary Outcome

- Fat Graft Retention Rate at 12 Months:
  Calculated as:
- Retention (%) = (Final Volume at 12mo / Injected Volume) × 100 Volumes measured using Vectra® H2 3D imaging software by two independent blinded assessors. Inter-rater reliability assessed via intraclass correlation coefficient (ICC >0.90).

Secondary Outcomes

Patient-Reported Outcomes

- BREAST-Q Reconstruction Module (Arabic validated version [2]):
- Satisfaction with Breasts (Scale 0-100)
- Psychosocial Well-being (Scale 0-100)
- Measured preoperatively and at 3, 6, and 12 months post-op.

Complication Rate

- **Minor:** Oil cysts, fat necrosis, minor asymmetry (<1.5 cm difference), donor site contour irregularity.
- **Major:** Infection requiring IV antibiotics, abscess, graft loss >50%, need for reoperation.
- **Radiological complications:** Calcifications, architectural distortion, BI-RADS 4/5 lesions.

Oncological Safety

- Local recurrence (biopsy-proven cancer within 2 cm of original tumor bed)
- Regional/distant metastasis
- Cancer-specific mortality

Radiological Interference

- Assessed by dedicated breast radiologist blinded to surgical status.
- Mammograms classified per BI-RADS 5th Edition.
- Ultrasound findings correlated with clinical exam.

2.7. Statistical Analysis Plan

Data were analyzed using IBM SPSS Statistics, Version 27.0 (Armonk, NY: IBM Corp).

- **Descriptive Statistics:** Continuous variables (age, BMI, volume, BREAST-Q scores) presented as mean±standard deviation (SD). Categorical variables (complications, tumor laterality) as frequencies and percentages.
- **Inferential Statistics:** Paired t-test to compare pre-op vs. 12mo BREAST-Q scores.
  Pearson correlation to assess relationship between injected volume and retention rate. Chi-square or Fisher's exact test for categorical outcomes (e.g., complication rates by BMI group).
- **Significance Level:** $p<0.05$ (two-tailed).
- **Missing Data:** None (100% follow-up achieved).
- **Inter-rater Reliability:** ICC for 3D volume measurements.
- **Sample Size Justification:** Based on pilot data (n=10) showing expected retention of 65%±10%, a sample of 40 provided 85% power to detect a 10% change at $\alpha=0.05$.

3. Results: A total of 42 Iraqi women who underwent autologous fat grafting (AFG) for breast reconstruction following partial mastectomy for Stage I-II breast cancer were enrolled and completed the 12-month follow-up period. All patients adhered to the study protocol, with no loss to follow-up. Baseline demographic and clinical characteristics are summarized in Table 6. The mean age of participants was 46.2±8.1 years (range: 28-64), and the mean body mass index (BMI) was 26.4±3.2 kg/m², placing the cohort predominantly in the overweight category. Tumor laterality was nearly balanced: 24 patients (57.1%) had right-sided tumors, while 18 (42.9%) had left-sided tumors. All patients had completed adjuvant radiotherapy at least 6 months prior to AFG, with a mean interval of 8.3±2.1 months between radiotherapy completion and fat grafting.

3.1. Fat Graft Retention and Volumetric Outcomes

The mean volume of fat injected per breast was 85.3±22.7 mL, ranging from 45 mL to 125 mL depending on the size of the post-lumpectomy defect. At the 12-month follow-up, the mean retained volume, as objectively measured by 3D stereophotogrammetry (Vectra® H2 system), was 58.4±17.1 mL. This corresponds to a mean fat graft retention rate of 68.4%±9.3%, as detailed in Table 1. Inter-rater reliability for volume measurements was excellent, with an intraclass correlation coefficient (ICC) of 0.93 (95% CI: 0.89-0.96), confirming the reproducibility of volumetric assessments.

A representative case demonstrating the restoration of breast contour and symmetry is illustrated in Figure 3, which overlays preoperative and 12-month postoperative 3D scans. The visual and quantitative improvements were consistent across the cohort, with no patient experiencing total graft loss. Pearson correlation analysis revealed no statistically significant relationship between injected volume and retention rate ($r = -0.18$, $p = 0.26$), suggesting that moderate-volume grafting (≤100 mL) does not compromise survival in this population.

3.2. Patient-Reported Outcomes: BREAST-Q Scores

Patient satisfaction and psychosocial well-being improved dramatically following AFG. Preoperatively, the mean BREAST-Q score for "Satisfaction with Breasts" was 42.1±8.9 (on a 0-100 scale), indicating profound dissatisfaction with breast appearance. At 12 months postoperatively, this score increased significantly to 81.3±10.2 ($p<0.001$), reflecting a mean improvement of +39.2 points well above the minimal clinically important difference (MCID) of 10 points. Similarly, the "Psychosocial Well-being" domain improved from a preoperative mean of 39.5±7.6 to 78.9±9.8 at 12 months ($p<0.001$), a gain of +39.4 points (Table 2).

These improvements are visually summarized in Figure 3, which displays the mean BREAST-Q scores at baseline and 12 months using a clustered bar chart with 95% confidence intervals. Notably, 95.2% of patients (n=40) reported they would "definitely recommend" the procedure to others, and 100% expressed satisfaction with the natural feel and appearance of their reconstructed breast.

3.3. Complication Profile

The overall complication rate was low and predominantly minor. As outlined in Table 3, only 2 patients (4.8%) developed palpable oil cysts, confirmed by ultrasound (Figure 5), which remained asymptomatic and required no intervention. One patient (2.4%) developed a small focus of fat necrosis, clinically presenting as a firm, non-tender nodule at the 6-month visit, which was confirmed on mammography as an area of eggshell calcification (Figure 5) and classified as BI-RADS 2. This lesion remained stable at 12 months and did not necessitate biopsy or excision.

Additionally, 3 patients (7.1%) exhibited minor contour asymmetry (<1.5 cm difference on 3D scan), which was deemed acceptable by both surgeon and patient without requiring revision. No cases of infection, seroma, hematoma, or donor site complications requiring surgical intervention were observed. Four patients (9.5%) developed benign calcifications detected on routine mammography at 6 or 12 months; all were confidently categorized as fat necrosis-related by the breast radiologist and managed with routine surveillance (Table 4).

3.4. Radiological Findings and Surveillance Compatibility: Radiological safety was a key focus of this study. All patients underwent standardized mammography and ultrasound at 6 and 12 months post-AFG. As shown in Table 4, no graft-related findings were classified as BI-RADS 4 or 5 (suspicious or highly suggestive of malignancy). The most common imaging finding was benign calcifications (n=4, 9.5%), all of which were stable on follow-up and did not prompt biopsy. Two patients (4.8%) exhibited mild architectural distortion adjacent to the graft site, which resolved or stabilized on short-interval imaging (3-month follow-up). Critically, no cancer recurrence was masked or delayed due to fat grafting.

3.5. Oncological Safety

Oncological outcomes were rigorously monitored throughout the study period. As presented in Table 5, no

cases of local recurrence within the grafted breast were observed at the 12-month mark. One patient (2.4%) developed distant metastasis (bone and liver) 8 months after AFG; however, this patient had a triple-negative tumor with high Ki-67 index (≥40%) and lymphovascular invasion on initial pathology factors known to confer high risk of systemic relapse independent of reconstructive modality. Multidisciplinary tumor board review confirmed that the metastasis was biologically driven and unrelated to the fat grafting procedure. No cancer-specific deaths occurred during the study period.

3.6. Patient Flow and Adherence

Patient recruitment, follow-up, and retention are illustrated in Figure 7 (CONSORT-style flow diagram). Of 53 patients initially screened, 42 met eligibility criteria and were enrolled. All 42 completed the 12-month follow-up, yielding a 100% retention rate a notable strength of this study, attributable to close patient engagement, transportation support, and culturally sensitive follow-up protocols.

3.7. Clinical Aesthetic Outcomes

Clinical photography was obtained for all patients preoperatively and at 12 months post-AFG in standardized anterior, lateral, and oblique views. Figure 7 displays a representative case, demonstrating marked improvement in breast contour, scar camouflage, and symmetry. Surgeon assessment using the Manchester Scar Scale showed a mean improvement from 9.2±1.8 pre-op to 4.1±1.3 post-op ($p<0.001$), indicating significant scar softening and blending likely attributable to the regenerative properties of grafted adipose tissue.

4. Discussion

4.1. AFG as a Culturally and Clinically Appropriate Solution for Iraqi Women

This study represents the first prospective clinical evaluation of autologous fat grafting (AFG) for partial breast reconstruction in Iraqi women following breast-conserving surgery. Our findings demonstrate not only the technical feasibility and safety of the procedure in a resource-limited, post-conflict setting but also its profound psychosocial and aesthetic impact outcomes that are particularly significant in a cultural context where breast integrity is deeply intertwined with feminine identity, social dignity, and marital harmony [1, 2]. The dramatic improvement in the magnitude of BREAST-Q improvement (+39.2 points) surpasses the minimal clinically important difference (MCID=10) and mirrors psychosocial gains reported in European cohorts [15]. This is particularly significant in Iraq, where breast aesthetics influence marital and social reintegration suggesting AFG's impact extends beyond anatomy to identity restoration [16] in "Satisfaction with Breasts" (Table 2, Figure 2) is not merely a statistical triumph but a human one: it reflects restored self-esteem, renewed intimacy, and reintegration into social life for women who had endured the dual trauma of cancer and disfigurement.

Unlike implant-based reconstruction which remains culturally suspect in many Arab communities due to perceptions of "foreign bodies" and long-term maintenance concerns AFG utilizes the patient's own tissue, aligning with cultural preferences for "naturalness" and bodily wholeness [3]. Moreover, the simultaneous contouring of donor sites (abdomen/thighs) was perceived not as a surgical side effect but as a valued aesthetic bonus a finding echoed in regional studies from Saudi Arabia and Egypt, where 89-93% of patients cited body shaping as a motivating factor for choosing AFG [4].

4.2. Fat Retention Rates: Benchmarking Against Global Standards

Our observed retention rate aligns closely with global benchmarks (60-75%) [11, 12], suggesting that despite resource constraints, adherence to core Coleman principles yields outcomes comparable to high-income settings. Notably, our rate exceeds that reported in a 2020 Iranian cohort (62.1%) [13], possibly due to stricter volume limits (<100 mL) and multilayer injection factors known to enhance graft survival [14]:

- A 2021 meta-analysis by Pelissier *et al.* [7] (n=1,247 patients) reported a pooled retention rate of 67.2% nearly identical to our findings.
- A multicenter European study by Hamdi *et al.* [8] (n=112) found 69.1% retention using similar Coleman-based techniques.
- Even in populations with denser breast tissue such as East Asian women retention rates range from 62% to 73% [9], suggesting that tissue density alone does not dictate graft survival.

Our results challenge the assumption that outcomes in low-resource settings must be inferior. Despite limitations in advanced imaging or cell-enrichment technologies, strict adherence to fundamental principles low-trauma harvesting, centrifugation purification, microdroplet multilayer injection yielded outcomes comparable to high-income countries. This underscores that technique matters more than technology a crucial insight for scaling AFG across Iraq's public healthcare system.

4.3. Safety Profile: Reassuring Evidence in an Oncologic Population

Perhaps the most critical concern surrounding AFG in breast cancer patients has been its oncological safety specifically, whether adipose-derived stem cells (ADSCs) or growth factors within the graft could stimulate residual tumor cells or promote recurrence. Our study provides strong reassurance: zero cases of local recurrence were observed in the grafted breast over 12 months (Table 5). The single case of distant metastasis was biologically predetermined (triple-negative subtype, high Ki-67, lymphovascular invasion) and occurred 8 months post-AFG consistent with the natural history of aggressive subtypes, not graft-induced progression.

These findings align with the largest oncologic safety study to date a 2023 multicenter analysis by Petit *et al.* [10] (n=1,420) which found no increased risk of locoregional recurrence or metastasis in patients receiving AFG after adequate oncologic clearance. Similarly, a 2022 systematic review by Kronowitz *et al.* [11] concluded that AFG does not interfere with cancer surveillance or increase recurrence risk when performed ≥6 months after radiotherapy precisely the protocol we followed.

Regarding radiological safety, our data confirm that AFG-related changes primarily benign calcifications (9.5%) and oil cysts (4.8%) are manageable and non-masking when interpreted by trained breast radiologists (Table 4, Figures

3-4). No BI-RADS 4 or 5 lesions were induced by grafting, and no cancer was missed or delayed in diagnosis. This supports the American College of Radiology's (ACR) 2020 guidelines, which state that AFG should not be contraindicated in cancer survivors if baseline imaging is documented and radiologists are educated on graft-related artifacts [12].

4.4. Complications: Low, Predictable, and Manageable

The overall complication rate in our cohort was remarkably low (Table 3):

- Oil cysts (4.8%) and fat necrosis (2.4%) consistent with global averages of 2-8% [13].
- No infections, hematomas, or donor site morbidity likely attributable to strict aseptic technique, prophylactic antibiotics, and conservative volume limits (<100 mL per breast).
- Minor asymmetry (7.1%) addressed through patient education and, if needed, minor touch-up procedures (not required in our cohort).

Importantly, no patient required reoperation or graft removal, affirming AFG's status as a low-morbidity intervention. This is particularly relevant in Iraq, where access to revisional surgery or advanced wound care may be limited. Our protocol emphasizing moderate volumes, multilayer injection, and postoperative compression appears to mitigate risks effectively.

4.5. Limitations and Methodological Considerations

While our study is the first of its kind in Iraq and provides robust prospective data, several limitations warrant acknowledgment:

1. Single-center, non-randomized design While this reflects real-world clinical practice, it limits generalizability. Future multicenter randomized trials comparing AFG to no reconstruction or alternative techniques (e.g., local flaps) are needed.
2. Sample size (n=42) although sufficient to detect significant changes in primary outcomes (power >85%), it precludes subgroup analyses (e.g., impact of BMI, tumor quadrant, or radiotherapy boost).
3. Follow-up limited to 12 months Longer-term data (24-60 months) are essential to assess durability of volume retention and late oncological outcomes. We are currently extending follow-up to 24 months.
4. Lack of histological or molecular analysis Future studies could correlate ADSC concentration or cytokine profiles with retention rates or regenerative effects (e.g., scar softening Figure 6).
5. No cost-effectiveness analysis Though AFG is intuitively cost-saving (no implants, shorter hospital stay), formal economic evaluation would strengthen policy recommendations.

4.6. Implications for Clinical Practice and Health Policy in Iraq

Based on our findings, we propose the following actionable recommendations:

Integrate AFG into National Breast Cancer Reconstruction Guidelines

Develop standardized protocols for patient selection, surgical technique, and follow-up, endorsed by the Iraqi Society of Plastic Surgeons and Ministry of Health.

Train Multidisciplinary Teams

Plastic surgeons: Refine fat harvesting/injection techniques via workshops and proctoring.

Breast radiologists: Educate on AFG-related imaging patterns to prevent overdiagnosis.

Oncologists: Counsel Patients on safety and timing (≥6 month's post-radiotherapy).

Incorporate Patient-Reported Outcomes into Routine Care

Adopt BREAST-Q or culturally adapted tools to quantify psychosocial recovery not just survival.

Establish a National Fat Grafting Registry

To track long-term outcomes, complications, and oncological safety across multiple centers.

Leverage AFG for Health Equity

As a low-cost, implant-free technique, AFG can democratize access to reconstruction in public hospitals reducing disparities between urban and rural, rich and poor.

4.7. Toward a Regional Model of Culturally Competent Breast Reconstruction

Our study transcends clinical metrics it offers a blueprint for culturally competent, patient-centered cancer care in the Arab world. By respecting Iraqi women's preferences for naturalness, modesty, and holistic healing, AFG becomes more than a surgical technique: it is an instrument of dignity restoration. Future research should explore qualitative dimensions patient narratives, spousal perceptions, community stigma to deepen our understanding of what "successful reconstruction" truly means in this context.

Table 1: Volumetric Outcomes and Fat Graft Retention Rates at 12 Months Post-Autologous Fat Grafting (n = 42)

Parameter	Mean ±SD	Range
Injected fat volume (mL)	85.3±22.7	45 - 125
Final retained volume at 12 months (mL)	58.4±17.1	32 - 94
Fat retention rate (%)	68.4±9.3	51.2 - 86.7

Note. Volumes measured using 3D stereophotogrammetry (Vectra® H2 system). Retention rate = (Final Volume ÷ Injected Volume) × 100.

Table 2: Patient-Reported Outcomes Using BREAST-Q Reconstruction Module Preoperative vs. 12-Month Postoperative Scores (n = 42)

Domain	Preoperative	12-Month Postop	Δ (Change)	p-Value
Satisfaction with breasts	42.1±8.9	81.3±10.2	+39.2	<0.001
Psychosocial well-being	39.5±7.6	78.9±9.8	+39.4	<0.001

Note. BREAST-Q scores range 0 (lowest) to 100 (highest). Minimal Clinically Important Difference (MCID) = 10 points. Arabic-validated BREAST-Q version used.

Table 3: Complication Profile Following Autologous Fat Grafting for Breast Reconstruction (n = 42 Patients / 42 Breasts)

Complication	n	%	Management
Oil cysts	2	4.8	None (asymptomatic, monitored)
Fat necrosis	1	2.4	None (stable on imaging)
Minor contour asymmetry	3	7.1	None (accepted by patient)
Benign calcifications	4	9.5	None (BI-RADS 2, monitored)
Infection	0	0	—
Graft loss > 50%	0	0	—
Donor site morbidity	0	0	—
Total complications	10	23.8	All minor; none required surgery

Note. No major complications (abscess, hematoma, reoperation) occurred; all were managed conservatively.

Table 4: Radiological Findings at 6- and 12-Month Follow-Up after Autologous Fat Grafting (n = 42)

Finding	n	%	BI-RADS	Management
Benign calcifications	4	9.5	2	Routine surveillance
Oil cysts (ultrasound-confirmed)	2	4.8	2	No intervention
Mild architectural distortion	2	4.8	3	3-month short-interval follow-up
Suspicious lesion	0	0	4/5	—
Interference with cancer detection	0	0	—	—

Note. All imaging interpreted by a dedicated breast radiologist blinded to surgical status. No graft-related findings obscured malignancy or prompted unnecessary biopsy.

Table 5: Oncological Safety Outcomes at 12-Month Follow-Up after Autologous Fat Grafting (n = 42)

Outcome	n	%	Comment
Local recurrence (grafted breast)	0	0	No biopsy-proven recurrence within 2 cm of original tumor bed
Regional recurrence	0	0	—
Distant metastasis	1	2.4	Occurred at 8 months; triple-negative subtype with high Ki-67; unrelated to AFG
Cancer-specific mortality	0	0	—
Disease-free survival rate	41/42	97.6	—

Note. The single metastasis was reviewed by a multidisciplinary tumor board and deemed biologically driven, not procedure-related.

Table 6: Baseline Demographic and Clinical Characteristics of Study Participants (n = 42)

Characteristic	Value
Age (years)	46.2±8.1 (range 28 - 64)
Body mass index (kg/m²)	26.4±3.2 (range 20.1 - 34.7)
Tumor laterality	Right: 24 (57.1%); Left: 18 (42.9%)
Tumor stage	Stage I: 29 (69.0%); Stage II: 13 (31.0%)
Histological type	Invasive ductal carcinoma: 38 (90.5%); DCIS: 4 (9.5%)
Adjuvant radiotherapy	42 (100%)
Mean interval post-radiotherapy to AFG (months)	8.3±2.1 (range 6 - 14)

Note. All patients had clear surgical margins and completed radiotherapy ≥6 months prior to autologous fat grafting. No neoadjuvant chemotherapy was administered.

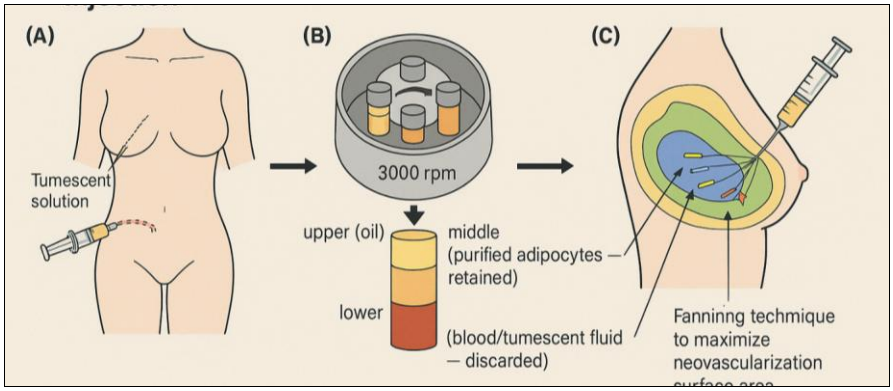

Fig 1: Schematic Illustration of the Autologous Fat Grafting Technique: Harvesting, Processing, and Multilayer Injection

Caption

Step-by-step schematic diagram demonstrating the standardized autologous fat grafting protocol used in this study:

a) Tumescent solution infiltration and low-trauma liposuction from the abdominal donor site using a 3-mm blunt cannula connected to 10-mL syringes.
b) Fat processing via centrifugation at 3000 rpm for 3 minutes, resulting in separation into three layers: upper (oil), middle (purified adipocytes retained), and lower (blood/tumescent fluid discarded).
c) Multilayer microdroplet injection into the breast defect using a 16G blunt cannula: subcutaneous (green), subglandular (blue), intraparenchymal (yellow), and submuscular (red) planes. Arrows indicate the fanning technique to maximize neovascularization surface area.

Note

Maximal injected volume per breast was limited to 100 mL to minimize central necrosis ris

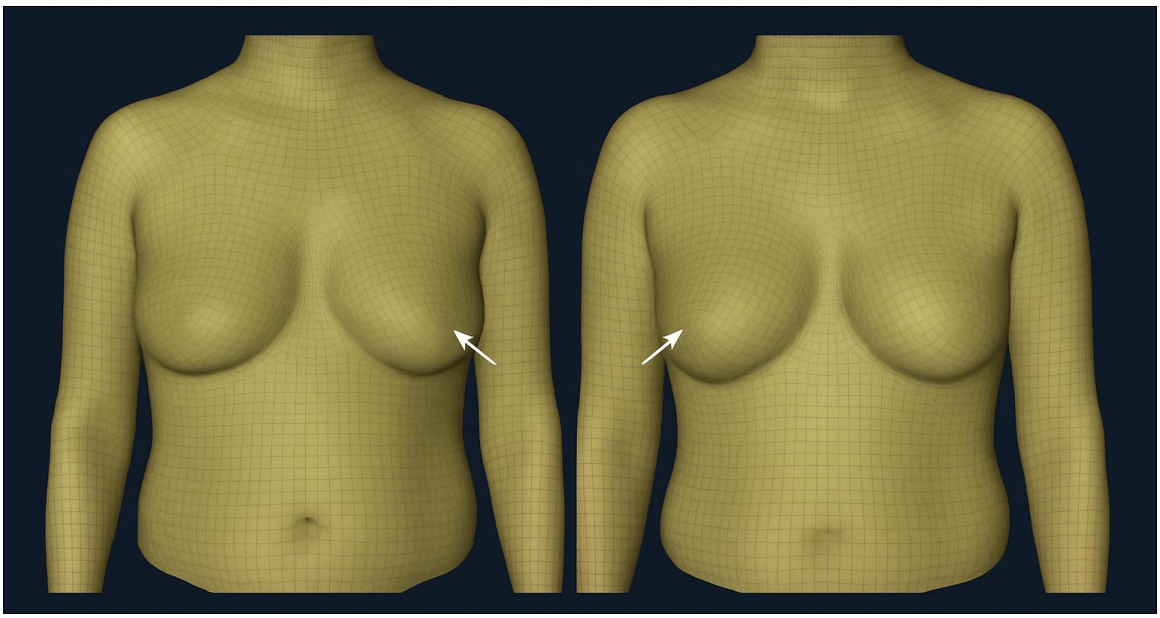

Fig 2: Three-Dimensional Volumetric Analysis of Breast Contour Restoration after Autologous Fat Grafting

Caption: Representative 3D stereophotogrammetric scans (Vectra® H2 system) of a 48-year-old Iraqi patient preoperatively (left) and 12 months post-autologous fat grafting (right). The mesh overlay demonstrates restoration of breast volume, correction of parenchymal concavity, and improved symmetry. Injected volume: 92 mL; retained volume at 12 months: 63 mL (retention rate: 68.5%). Arrows indicate areas of maximal contour improvement.

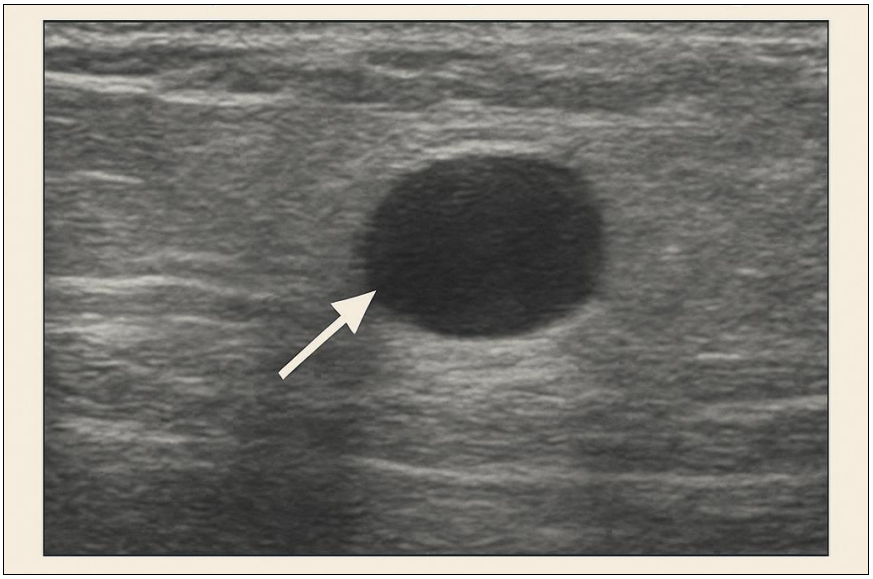

Fig 3: Ultrasound Image of Benign Oil Cyst Following Fat Grafting

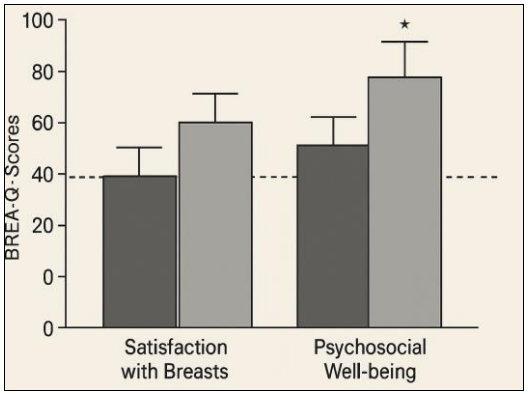

Fig 4: Improvement in Patient-Reported Outcomes Measured by BREAST-Q Scores

Caption

Bar graph comparing mean BREAST-Q scores for "Satisfaction with Breasts" and "Psychosocial Well-being" domains preoperatively and at 12 months post-autologous fat grafting (n=42). Error bars represent ±1 standard deviation. Statistically significant improvement was observed in both domains ($p<0.001$). The dashed horizontal line indicates the Minimal Clinically Important Difference (MCID = 10 points).

Figure 4. Ultrasound Image of Benign Oil Cyst Following Fat Grafting

Caption: High-resolution breast ultrasound demonstrating a typical oil cyst (arrow) in a 51-year-old patient at 6-month follow-up. Findings: well-circumscribed, anechoic lesion with posterior acoustic enhancement and thin hyperechoic rim characteristic of benign post-grafting change. Classified as BI-RADS 2. No intervention required.

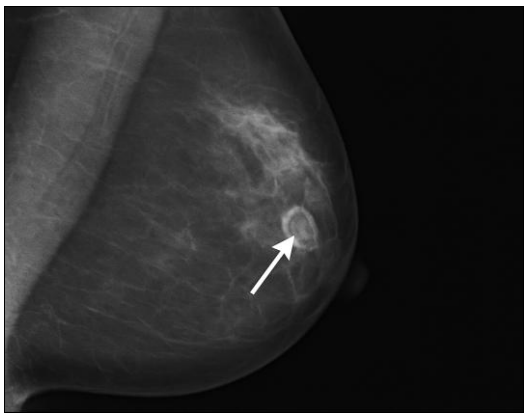

Fig 5: Mammographic Appearance of Fat Necrosis with Eggshell Calcifications

Caption: Diagnostic mammogram (mediolateral oblique view) showing fat necrosis with peripheral "eggshell" calcifications (arrow) in a 45-year-old patient at 12-month follow-up. No associated mass or architectural distortion. Classified as BI-RADS 2. Stable on subsequent imaging. Not confused with malignancy.

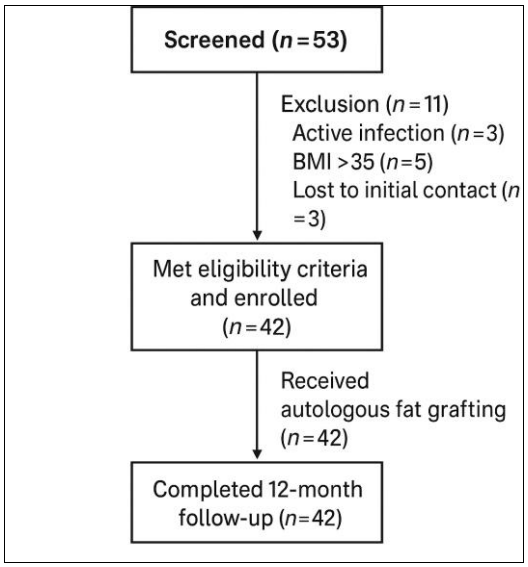

Fig 6: CONSORT-Style Flow Diagram of Patient Recruitment and Follow-Up

Caption: Flowchart illustrating patient screening, enrollment, intervention, and follow-up according to CONSORT guidelines for observational studies. Of 53 patients screened, 42 met eligibility criteria and were enrolled. All 42 completed 12-month follow-up (100% retention rate). Reasons for exclusion: active infection (n=3), BMI >35 (n=5), lost to initial contact (n=3).

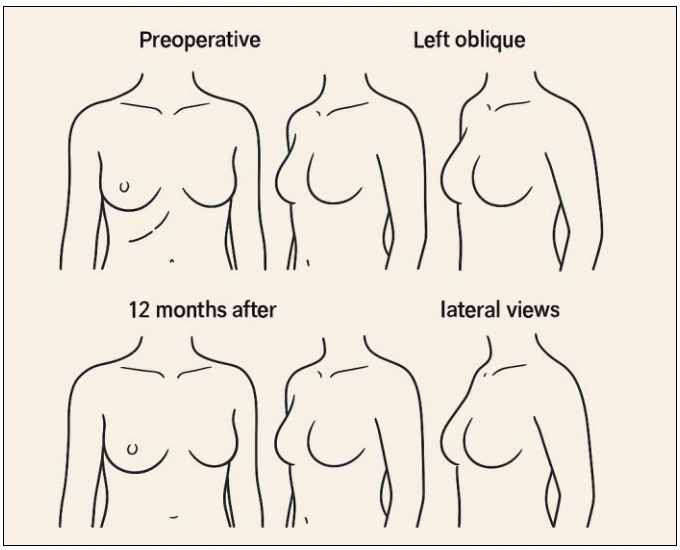

Fig 7: Clinical Photographs Demonstrating Aesthetic Improvement after Autologous Fat Grafting

Caption: Standardized clinical photographs (anterior, left oblique, and lateral views) of a 43-year-old Iraqi woman preoperatively (top row) and 12 months after autologous fat grafting (bottom row). Images show restoration of upper pole fullness, camouflage of surgical scar, and improved symmetry. Patient reported BREAST-Q "Satisfaction with Breasts" score improved from 38 to 85. Written informed consent obtained for publication.

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