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The impact of immediate lipofilling on oncological outcomes, complication rates and patient reported outcomes in breast conserving surgery: a systematic review and meta-analysis

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ABSTRACT

Background: There is concern from in-vitro studies that adipose-derived stem cells could promote cancer recurrence through their proliferative properties. The impact of immediate lipofilling (ILF) in the setting of breast conserving surgery (BCS) on oncological outcomes, complications and patient-reported outcomes are unknown.
Methods: A systematic search of Medline, Embase and Cochrane Central was conducted for studies investigating the impact of ILF in patients undergoing BCS. Random-effects meta-analysis were conducted for oncological outcomes (local [LR], regional [RR], distant [DR] and overall recurrence).
Results: Six studies fulfilled the inclusion criteria including 252 patients. The pooled LR, RR, DR and overall recurrence rates were 2.38 %, 1.52 %, 3.03 % and 5.95 %, respectively (median follow-up, 39 months). A meta-analysis of studies comparing ILF (n = 170) with no-ILF (n = 362) found no difference in LR (OR, 0.77; 95 % CI, 0.19–3.17; p = 0.714), RR (OR 1.73, 95 % CI 0.36–8.21, p = 0.686), DR (OR 1.37, 95 % CI, 0.51–3.63; p = 0.627) or overall recurrence (OR 1.23, 95 % CI, 0.60–2.52; p = 0.569). Cancer-specific survival in the ILF group was 100 % compared to 98.7 % with no-ILF. Post-operative calcifications (12.9 % [21/163] vs. 0 %; [0/72], p = 0.002) and fat necrosis (7.8 % (17/217] vs. 2.8 % [8/283], p = 0.011) were significantly more common with ILF, but early complications (e.g. haematoma and infection) showed no difference (p > 0.05). Three studies reported superior Breast-Q scores in ILF compared to no-ILF. No randomised controlled trials have been conducted.
Conclusion: Immediate lipofilling following BCS appears oncologically safe, enhances aesthetic outcomes and causes minimal morbidity, but higher-quality studies are required.

1. Introduction

As a minimally invasive reconstructive procedure, lipofilling also known as autologous fat grafting can improve some of the aesthetic complications, including asymmetry and contour deformities seen after breast-conserving surgery (BCS) as well as reversing radiation-induced changes (e.g. fibrosis, atrophy and radiodermatitis) [1–4]. Despite the obvious improvements seen with lipofilling, there remain concerns about its oncological safety, as the material injected contains stem cells and growth factors that could potentially increase the rate of proliferation of any residual breast cancer cells and thus potentially promote local recurrence. In-vitro and animal studies indicate that the adipose-derived stem cells in some of these models can increase local cancer recurrence through mechanisms affecting residual cancer cells including angiogenesis [5–7]. To counterbalance, other pre-clinical studies have suggested that adipose stem cells could have a protective effect on recurrence [8–11].

To minimise the risk of the activation of dormant cancer cells, delaying lipofilling following adjuvant treatments is often advised [12, 13]. Systematic reviews of delayed lipofilling (performed years after initiation of adjuvant therapies), have demonstrated its safety without an elevated local recurrence rate [14–19]. Its safety has also been demonstrated as a delayed procedure following mastectomy and immediate reconstruction [20].

Breast conserving surgery can result in asymmetry of volume and shape between the two breasts. To correct this with lipofilling usually requires between 2 and 4 episodes of lipofilling. Immediate lipofilling (ILF) was developed as a method to try and avoid asymmetry and

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distortion in the hope that if performed simultaneously with the cancer resection, a single episode of lipofilling would be sufficient to maintain long-term symmetry. Any residual disease in the breast, even if affected by ILF, will be later treated by both radiotherapy and systemic therapy. This is however theoretical and the potential for ILF to impact local recurrence is unknown; as to date, series published are small and a meta-analysis has not been performed [21,22]. ILF also needs to be evaluated in the context of complications (e.g. fat necrosis, calcifications) and patient reported outcome measures (PROMs) [10,23,24]. Any potential aesthetic benefit must be weighed up against the oncological outcomes, risk of complication and biopsy during cancer follow-up.

The aim of this meta-analysis was to investigate the impact of ILF on oncological outcomes (local, regional, distant and overall recurrence), complications as well as PROMs.

2. Methods

This meta-analysis investigates the impact of ILF on oncological outcomes following BCS. The inclusion criteria were patients undergoing ILF during the same procedure as BCS. Primary outcomes were oncological outcomes including local (LR), regional (RR), distant (DR) and overall recurrence. Secondary outcomes were cancer-specific survival (CSS), complications, PROMs and the need for further volume replacement. Particular attention was paid to studies reporting Breast-Q outcomes, a validated tool to assess patient reported outcomes [25–27].

2.1. Literature search

A systematic search of MEDLINE (OVID), EMBASE, and the Cochrane Central Register of Controlled Trials (CENTRAL) was conducted from their date of inception to March 1st' 2025. The following query of keywords were employed: "immediate lipofilling", "lipofilling", "fat grafting", " fat transfer", "fat transplantation", "breast conserving surgery", "BCS", "wide local excision", "WLE", "recurrence", "locoregional recurrence ", "local recurrence".

2.2. Eligibility and exclusion criteria

Both studies comparing ILF with no-ILF and non-comparative studies were included. Studies investigating delayed lipofilling were excluded and patients who underwent delayed lipofilling were not included in the no-ILF group. In cases where the median time from BCS and lipofilling was reported but there was no explicit mention of ILF, these studies were excluded. Cases where ILF was an adjunctive procedure to reconstruction (e.g. latissimus dorsi flap) were excluded as were studies that reported free dermal fat grafts. In summary the following studies were excluded.

- Studies reporting delayed lipofilling
- Studies reporting ILF after mastectomy
- Studies reporting outcomes of ILF in a mixed group (BCS and mastectomy) without subgroup analysis
- Studies including ILF as an adjunct to additional reconstructive approaches
- Studies including previously published data
- Studies reporting free dermal fat grafts
- Studies reporting BCS for benign indications
- Studies not published in English
- Studies reporting less than 10 cases

2.3. Study selection and data points and extraction

Title and abstract screening were conducted independently by two reviewers (JL and HB) following deduplication. Where there was disagreement regarding the suitability of studies for full-text review, a third party (MD) was consulted to resolve any discrepancies. A comprehensive overview of the screening process is provided in the PRISMA flow diagram (Fig. 1).

2.4. Study selection and data points and extraction

Detailed review of the full texts to confirm eligibility based on inclusion and exclusion criteria was then performed. The data were extracted using a predefined extraction sheet, which can be provided upon reasonable request. Following extraction, the reviewers compared the data, addressing any inconsistencies through discussion.

2.5. Statistical analysis

The pooled median follow-up was estimated across all studies. For each study, the number of events and the total number of participants in the intervention (ILF) and control (no-ILF) groups were extracted. The rates of LR, RR, DR and overall recurrence were reported and using all available data, the pooled rates were calculated for the ILF group. We calculated study-specific log odds ratios (log ORs) and their variances using the “escalc” function from the “metafor” package in R Studio. A continuity correction of 0.1 was applied to studies with zero events in one or more groups to avoid division by zero and improve stability of the log OR estimates in small samples. A random-effects meta-analysis was performed using the restricted maximum likelihood (REML) estimator via the “rma” function in “metafor”, which accounts for between-study heterogeneity. The pooled effect size was expressed as an OR with corresponding 95 % confidence intervals (CI), obtained by exponentiating the summary log OR and its CI. Heterogeneity across studies was assessed using the I^2 statistic. Forest plots were constructed using the “metafor:forest” function, with OR presented on a log scale and back-transformed for interpretability.

Complication rates were extracted, and the pooled complication rates were reported. The chi-squared test was used to compare rates between the ILF and the no-ILF group. Studies reporting PROMs (e.g. Breast-Q scores) were investigated and the overall weighted mean score for each question was calculated. The weighted means of the ILF and no-ILF groups were compared. In the Breast-Q analysis the scoring was as follows: satisfied (4), somewhat satisfied (3), somewhat dissatisfied (2), dissatisfied (1).

Funnel plots were used to visually assess publication bias, though their interpretation was limited due to the small number of included studies and low event rates. The certainty of the evidence for each outcome was assessed using the GRADE (Grading of Recommendations, Assessment, Development and Evaluation) approach, considering risk of bias, inconsistency, indirectness, imprecision, and publication bias.[59] Ratings were classified as high, moderate, low, or very low certainty in accordance with GRADE guidance.

3. Results

3.1. Study characteristics

Overall, six observational studies and a total of 252 patients (range, 30–65) receiving ILF following BCS for breast tumours fulfilled the inclusion criteria (retrospective n=5, prospective n=1) [Table 1]. Four studies compared outcomes with no-ILF groups, one of which included a matched analysis. Characteristic comparison between the ILF and no-ILF groups revealed comparable groups in two studies, while Khan et al. found larger tumours in the ILF group ($p = 0.011$) and Stumpf et al. found a higher rate of chemotherapy in the ILF group before matching [28,29]. Due to the studies' observational nature, small sample sizes, and low event rates, the certainty of the evidence for oncological outcomes, complication rates, and PROMs was rated as ‘very low’ according to the GRADE approach (Supplementary Table 1).

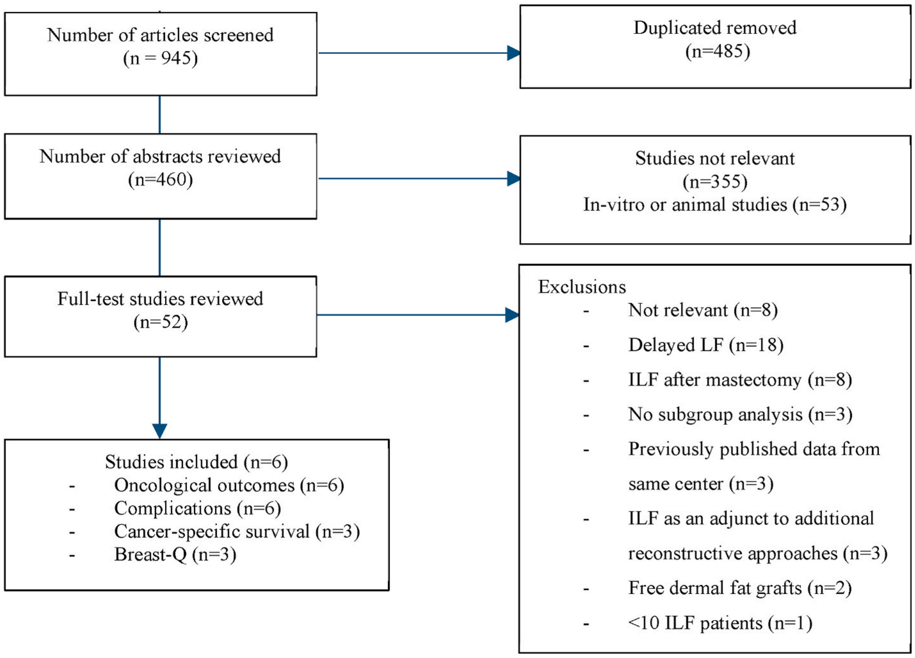

Fig. 1. PRISMA-flow diagram.

Table 1
Study characteristics.

Author	Year of study	Study Type	Dates of patient data	Country	ILF number	Comparison with non lipo (Y/N)	no-ILF number	Differences in characteristics between groups	Matched analysis (Y/N)
Li et al. [32]	2021	R, S	2016–2017	China	30	Y	28	No significant differences	N
Khan et al. [29]	2017	R, S	2011–2014	United Kingdom	35	Y	39	Tumours larger in ILF group (p = 0.011)	N
Gong et al. [21]	2022	R, S	2018	China	40	Y	40	No significant differences	N
Ahmed et al. [30]	2022	P, S	2016–2018	Egypt	54	N	N/A	N/A	N
Stumpf et al. [28]	2020	R, S	2004–2016	Brazil	65	Y	255	Higher BMI in non-ILF group Higher rate of chemo in ILF group	Y
García et al. [31]	2014	R, S	NR	Spain	28	N	NR	Not applicable	N

*R – retrospective; P – prospective; S – single centre; M − multiple centres.

3.2. Cohort characteristics

Three studies reported hormone receptor status and the patients treated in these studies included 77.0 % ER positive tumours and 19.3 % HER2-positive tumours (Supplementary Table 2). Overall, 54.1 % of tumours were histological grade-2 and 25.2 % were grade-3. At least 98.5 % of patients received radiotherapy across all studies. In those that reported axillary status, between 23.3 % and 40.0 % had axillary metastasis preoperatively. Ductal carcinoma in situ (DCIS) and invasive lobular cancers were generally absent or minimal, excluding Ahmed and Stumpf et al. who included 24.1 % and 16.9 % of invasive lobular cancers, respectively [28,30]. The average volume resected and volume of fat grafted into the breast ranged from 47 to 88.9 mL and 74 to 128.2 mL, respectively.

Three studies reported re-excision rates of 7.1 % (2/28), 12.3 % (6/65) and 22.9 % (8/35) in the ILF groups [28,29,31]. One study reported a re-excision rate of 17.3 % (44/255) in the no-ILF group [28]. All cases of re-excision resulted in negative margins. Three studies reported using frozen section to reduce the likelihood of positive margins [21,28,32].

3.3. Oncological outcomes

The median follow-up duration ranged between 30 and 60 months. The pooled LR, RR, DR and overall recurrence rates were 2.38 %, 1.52 %, 3.03 % and 5.95 %, respectively (pooled median follow-up, 39 months) (Table 2, Fig. 2).

The meta-analysis of studies comparing ILF ($n = 170$) with no-ILF ($n = 364$) found no difference in LR (OR, 0.77; 95 % CI, 0.19–3.17; $p = 0.714$), RR (OR 1.73, 95 % CI 0.36–48.21, $p = 0.686$), DR (OR 1.37, 95 % CI, 0.51–3.63; $p = 0.627$) or overall recurrence (OR 1.23, 95 % CI, 0.60–2.52; $p = 0.569$) (Fig. 3). The cancer-specific survival in the ILF group was 100 % compared to 98.7 %. Assessment of publication bias was limited due to the number of included studies, but in all cases I^2 was $\leq$40 % (Supplementary Fig. 1).

Stumpf et al. reported a slightly higher overall recurrence rate in the ILF group (12.3 % vs. 8.6 %), although the single case of local recurrence in the ILF group occurred at a different site from the initial cancer [28]. The explanation provide for this case was the omission of adjuvant treatment. Similarly, of the three local recurrences reported by Ahmed et al., no cases of local recurrence occured at the site where ILF was performed [30].

Table 2
Oncological and survival outcomes.

Author	Median/average Follow-up	Local recurrence (LR), %		Regional recurrence (RR), %		Distant recurrence (DR), %		Overall recurrence, %		Cancer-specific Survival, %	
		ILF	no-ILF	ILF	no-ILF	ILF	no-ILF	ILF	no-ILF	ILF	no-ILF
Li et al.	39	0 (0/30)	0 (0/28)	3.7 (1/30)	0 (0/28)	0 (0/30)	3.8 (1/28)	3.7 (1/30)	3.8 (1/28)	NR	NR
Khan et al.	36	0 (0/35)	0 (0/39)	0 (0/35)	0 (0/39)	0 (0/35)	0 (0/39)	0 (0/35)	0 (0/39)	100	100
Gong et al.	41	5.0 (2/40)	5.0 (2/40)	0 (0/40)	0 (0/40)	2.5 (1/40)	5.0 (2/40)	7.5 (3/40)	10 (4/40)	100	97.5
Ahmed et al.	31	5.6 (3/65)	N/A	NR	N/A	NR	N/A	5.6 (3/65)	N/A	NR	N/A
Stumpf et al.	60	1.5 (1/65)	2.7 (7/255)	3.0 (2/65)	1.2 (3/255)	7.7 (5/65)	4.7 (12/255)	12.3 (8/65)	8.6 (22/255)	NR	NR
García et al.	30	0 (0/28)	N/A	0 (0/28)	N/A	0 (0/28)	N/A	0 (0/28)	N/A	100	NR

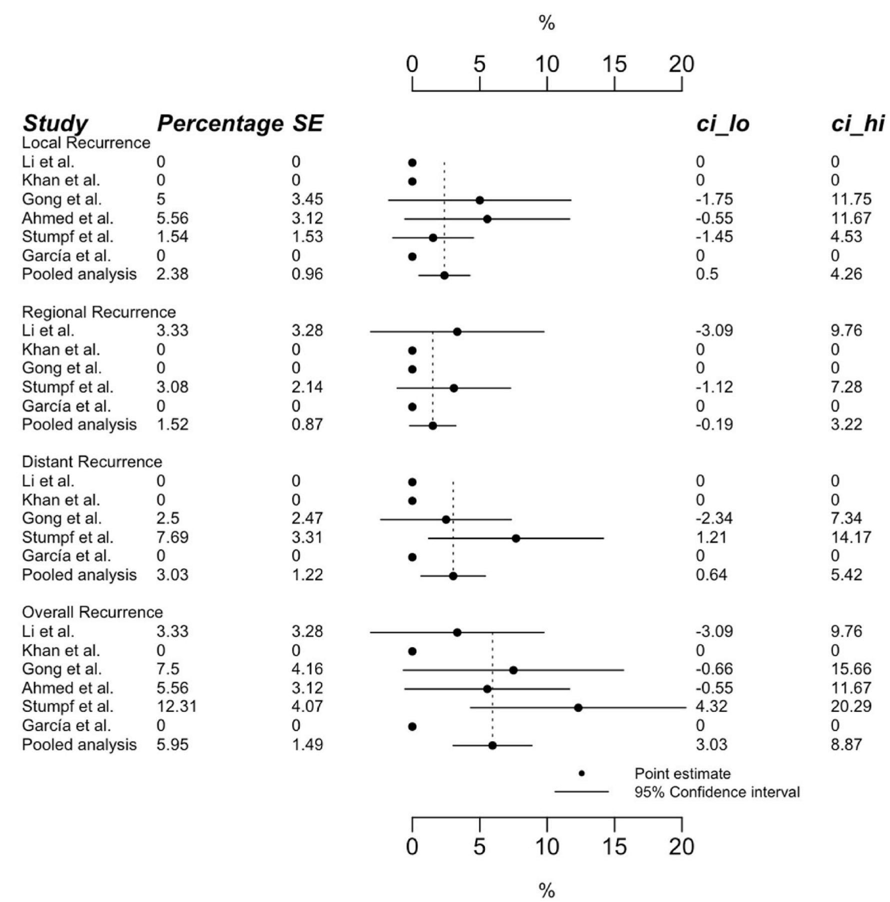

Fig. 2. Pooled oncological outcomes (LR, RR, DR and overall recurrence) following ILF for all studies reporting recurrence.

3.4. Complications

The pooled complication rates were as follows: calcifications, 12.9 % (11/163); fat necrosis/oil cysts, 7.8 % (17/217); seroma, 4.3 % (8/188); infection, 2.8 % (6/217) and haematoma, 0.8 % (1/124) (Supplementary Table 3). The rate of post-operative calcification was significantly higher in the ILF group (12.9 %; 21/163) compared to the no-ILF group (0 %; 0/72) ($p = 0.002$). Similarly rates of fat necrosis were significantly higher in the ILF group (7.8 % (17/217)] vs. 2.8 % [8/283], $p = 0.011$). There were no significant differences in early complications (haematoma, infection or seroma; $p > 0.05$) between ILF and no-ILF. No cases of repeat biopsies following ILF were reported in the studies.

3.5. Patient reported outcome measures

Table 3 reports the Breast-Q scores of three studies comparing ILF and no-ILF, each reporting outcomes at median follow-up times of 2, 36 and 39 months. For all outcomes measures, the scores were >3 (between somewhat-satisfied [3] and satisfied [4]) in the ILF group and were superior to the no-ILF group. For example, the weighted mean across the three studies of “How satisfied are you with how you look in the mirror clothed?” was 3.66 (ILF) compared to 3.31 (no-ILF). Furthermore, the weighted mean of “How satisfied are you with the smoothness of your operated breast?” was 3.38 compared to 2.83, respectively. Gong et al. found a higher overall Breast-Q score in ILF compared to no-ILF (57.8 vs.

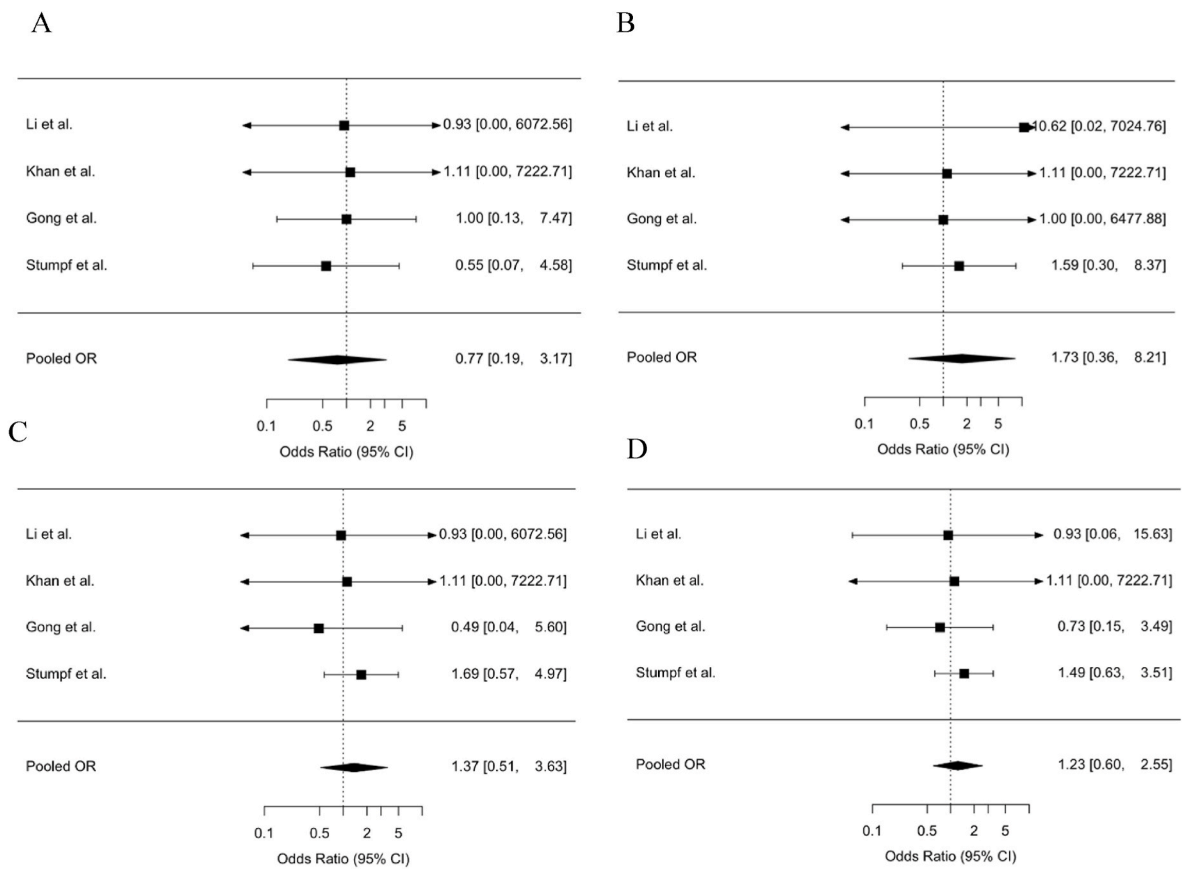

Fig. 3. Pooled analysis of studies comparing LR (A), RR (B), DR (C) and overall recurrence (D) outcomes between ILF (n = 170) and no-ILF (n = 362).

51.9; p < 0.001).

The review by Khan et al. also noted lower rates of tenderness (p = 0.003), sharp pain (p < 0.001), shooting pain (p = 0.018), aching feeling (p < 0.001) and throbbing feeling (p = 0.007) in the ILF group [29]. This paper also observed that the ILF group had improved scarring compared to the no-ILF group although this was not formally assessed. Li et al. assessed cosmesis through a 4-point Likert scale and found that ILF had better cosmesis (p = 0.075) [32]. In the paper by Garcia, 90 % of patients were very satisfied in the ILF group.

Ahmed et al. found that 79.6 % of patients had satisfaction following BCS and ILF and that overall satisfaction was associated with a lower fat resorption rate [30]. Of those that were not satisfied (20.4 %), 9 of 11 of these patients were satisfied following a second lipofilling session. No other subgroup or study reported using delayed lipofilling following ILF.

4. Discussion

This is the first systematic review and meta-analysis investigating the impact of immediate lipofilling (ILF) following breast-conserving surgery (BCS). Across six studies, the cohort represents the largest pooled analysis of ILF patients and reports acceptable rates of local (2.38 %), regional (1.52 %), distant (3.03 %) and overall recurrence (5.95 %) over a median follow-up of 39 months. A comparative meta-analysis of matched studies showed no statistically significant difference in oncological outcomes (e.g. local recurrence, OR, 0.77; 95 % CI, 0.19–3.17; p = 0.714) compared with patients who did not receive ILF. The findings of this meta-analysis suggest that ILF does not appear to increase the likelihood of recurrence and is consistent with the conclusions made by at least six systematic reviews investigating the safety of delayed lipofilling [13,16–19,24].

The pooled recurrence and the cancer-specific survival rates reported in this study are consistent with the wider literature reporting contemporary outcomes after BCS [33–35]. The present pooled cohort included T1-3 tumours (77.0 % ER-positive tumours; 19.3 % HER2-positive), nearly all of which received adjuvant radiotherapy. The reported recurrence rates are consistent for these tumour subtypes treated by BCS in the literature [35–40]. Furthermore it is reassuring that the studies included in this meta-analysis utilised a matched analysis with comparable variables between groups. The exception to this observation was that larger tumours were treated with ILF in the study by Khan et al.; although, no local recurrences were reported in this study [29].

The optimal timing of lipofilling is unclear; whilst ILF raises theoretical concerns of adipose-derived stem cells potentially promoting proliferation of residual tumour cells, BCS patients receive adjuvant treatments after ILF including whole breast radiotherapy. A few studies have investigated the impact of the timing of lipofilling. Silva-Vergara et al. reviewed 205 cases of delayed lipofilling following BCS and found an increased risk of loco-regional recurrence when lipofilling was performed <36 months after surgery; however, lipofilling within 1 or 5 years was not associated with higher recurrence in the studies by Krastev et al. and Sorrentino et al. [41–43] Notably, two of the studies included in this meta-analysis found no recurrences at the site of lipofilling and the findings help confirm that ILF does not translate into a measurable clinical increase in recurrence risk [28,30].

While ILF was associated with a higher incidence of fat necrosis and benign calcifications, no study reported any increase in the rate of post-BCS biopsy during follow-up or an increase in the rate of early complications. Nevertheless, the repercussions of fat grafting on breast imaging should not be overlooked: calcifications have been reported in up to 21 % of patients, oil cysts in up to 85 % and further biopsy in up to 10.8 % [15,44–46]. This may be technique related as the study by Khan et al. reported calcifications in only a single patient and no evidence of fat necrosis. In this study, the authors initially performed centrifugation but

Table 3
Breast-Q scores: ILF vs. no-ILF.

Outcome measure	Author			Weighted Mean of all studies	
	Li et al. (ILF, n = 26; no-ILF, n = 26; median follow-up 39 months)	Khan et al. (ILF, n = 32; no-ILF, n = 39; median follow-up 36 months)	Gong et al. (ILF, n = 40; no-ILF, n = 40; follow-up 2 months)	ILF	No-ILF
Breast-Q score	NR	NR	57.8 vs. 51.9 ($p < 0.001$)	57.8	51.9
How satisfied are you with how you look in the mirror clothed?	3.42 vs. 2.88; ($p = 0.005$)	3.84 vs. 3.56 ($p < 0.001$)	3.70 vs. 3.4 (NR)	3.66	3.31
How satisfied are you with the shape of your operated breast in bra?	3.38 vs. 3.00 ($p = 0.120$)	3.81 vs. 3.56 ($p < 0.001$)		3.62	3.45
The shape of your lumpectomy breast when you are wearing a bra	NR	NR	3.53 vs. 3.28 (NR)	3.53	3.28
How normal you feel in your clothes.	NR	NR	3.78 vs. 3.30 (NR)	3.78	3.30
Able to wear fitted clothing?	3.58 vs. 3.04 ($p = 0.081$)	3.72 vs. 3.38 ($p < 0.001$)	3.33 vs. 2.93 (NR)	3.52	3.11
How your lumpectomy breast sits/hangs	NR	NR	3.33 vs. 3.08 (NR)	3.33	3.08
How satisfied are you with the smoothness of your operated breast?	3.50 vs. 2.96 ($p = 0.014$)	NR	3.30 vs. 2.75 (NR)	3.38	2.83
How satisfied are you with the size of your operated breast	NR	3.69 vs. 3.33 ($p < 0.001$)		3.69	3.33
The contour (outline) of your lumpectomy breast	NR	NR	3.33 vs. 2.78 (NR)	3.33	2.78
How equal in size your breasts are?	3.50 vs. 2.92; ($p = 0.197$)	3.56 vs. 2.82 ($p < 0.001$)	3.23 vs. 2.95 (NR)	3.41	2.90
How normal your lumpectomy breast looks	NR	P = 0.0482	3.10 vs. 2.78 (NR)	3.10	2.78
How closely matched your breasts are	NR	3.47 vs. 3.03 ($p < 0.001$)	3.08 vs.2.78 (NR)	3.25	2.89
How satisfied are you with how you look in the mirror unclothed?	3.35 vs. 2.73 ($p = 0.007$)	3.34 vs. 2.92 ($p < 0.001$)	2.98 vs. 2.80 (NR)	3.20	2.82
Overall cosmesis	NR	3.63 vs. 3.28 ($p < 0.001$)	NR	3.63	3.28
Psychosocial well being	$p < 0.001$ (higher in ILF)	NR	NR	NR	NR

*NR – not reported.

later transitioned to fat washing; other studies have reported greater fat necrosis and lower volumes of fat retention with centrifugation [47–50]. Certain principles can be utilised to optimise volume maintenance whilst minimising complications: 1) injecting over a wide area into vascularised tissue 2) washing out loose fat at the end of the procedure 3) closing the defect with a barbed suture left loose rather than with tight single sutures that can cut though and cause tissue damage 4) individualising the procedure [51,52].

Unlike delayed lipofilling, which often requires 2–4 procedures, the findings in this meta-analysis suggest that ILF allows for immediate volume restoration and in most cases does not require further sessions of lipofilling. ILF also improves aesthetic outcomes, improves psychosocial well-being and leads to medium-term preservation of cosmesis (range of follow-up 2–39 months). Three studies reported significantly higher Breast-Q scores in the ILF group compared to no-ILF, with pooled weighted means demonstrating consistent improvements across domains such as breast symmetry, contour, and satisfaction with appearance. The benefits of lipofilling to reverse radiation-induced changes (e.g. correction of contracture and fibrosis) are well established, but the present analysis also demonstrates promising outcomes from pre-emptive fat grafting prior to radiotherapy [53,54]. Although the underlying mechanisms behind this finding are incompletely understood, there are several hypotheses. 1) Firstly, adipose-derived stem cells have regenerative properties which may protect against radiation-induced fibrosis [7,11]. 2) Earlier lipofilling into a well-vascularised tissue bed prior to radiotherapy may reduce resorption and improve fat graft survival. 3) Lastly, pre-emptive correction of volume deficits may also allow radiotherapy to be delivered more evenly, reducing areas of fibrosis or contracture due to irregular dosing.

There is some consistent evidence that lipofilling may improve pain following breast surgery, particularly in post-mastectomy pain [55–58]. Although pain was not an outcome explored by many of the included studies, Khan et al. found that ILF reduces rates of breast tenderness, sharp pain, shooting pains, aching and throbbing compared to patients who do not receive ILF. Unfortunately, studies investigating the impact of lipofilling (including delayed lipofilling) on post-operative pain following BCS are extremely limited and therefore further investigation is required to confirm this finding.

Overall, the decision between immediate and delayed lipofilling depends on multiple factors including tumour characteristics, adjuvant treatment and logistical considerations. Since the underlying biological interaction between lipofilling and tumour proliferation remains undetermined in pre-clinical studies and little clinical data exists in higher risk tumours (e.g. TNBC), ILF should be limited to lower-risk tumours. ILF should also only be considered when adjuvant therapy is unlikely to be delayed or omitted such that any residual tumour cells can be treated. If these criteria are met, then ILF should be considered to restore cosmesis as a single session, potentially reducing any psychological or physical burden. Delayed lipofilling may be more appropriate in cases where oncological clearance and margin status are uncertain or in cases of post-radiotherapy volume loss or contour deformity.

The quality of evidence included in this review was limited by the absence of randomised controlled trials (RCTs), the small sample, study heterogeneity (e.g. fat injection technique) and short-term follow-up of studies. Due to these limitations, the certainty of the evidence was rated as very low according to the GRADE approach. Future studies should either be RCTs or perform adequate propensity score matching of larger cohorts with longer follow-up to yield more meaningful analysis. The lack of TNBC patients and patients receiving NAC limits the generalisation to higher risk groups. Other aspects that could be addressed in future studies include the length of time it takes to perform ILF, its resource implications and the impact of ILF on volume excision and positive margins.

In summary, this is the first meta-analysis to investigate outcomes of ILF and the results suggest that ILF does not appear to increase the likelihood of recurrence following BCS. ILF may be associated with improved aesthetic outcomes, higher patient satisfaction, and low morbidity, despite the risk of fat necrosis and calcification. These findings highlight ILF as a viable and attractive reconstructive option. Further high-quality research including RCTs and long-term prospective studies are essential to confirm these findings.

Credit author statement

James Lucocq – Conceptualization, Methodology, Software, Formal analysis, Investigation, Resources, Data Curation, Writing - Original Draft, Visualization, Project administration; **Hassan Baig** – Methodology, Validation, Investigation; **Professor J Michael Dixon** – Conceptualization, Methodology, Writing - Original Draft, Writing - Review & Editing, Supervision.

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none.

Declaration of interest statement

There are no conflicts of interest to declare by James Lucocq, Hassan Baig or Professor Mike Dixon.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ejso.2025.110446.

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