

# Radiotherapy and breast reconstruction: a meta-analysis

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**Abstract** The optimum sequencing of breast reconstruction (BR) in patients receiving postmastectomy radiation therapy (PMRT) is controversial. A comprehensive search of published studies that examined postoperative morbidity following immediate or delayed BR with combined radiotherapy was performed. Medical (MEDLINE & EMBASE) databases were searched and cross-referenced for appropriate studies where morbidity following BR was the primary outcome measured. A total of 1,105 patients were identified from 11 appropriately selected studies. Patients undergoing PMRT and BR are more likely to suffer morbidity compared with patients not receiving PMRT (OR = 4.2; 95% CI, 2.4–7.2 [no PMRT vs. PMRT]). Reconstruction technique was also examined with outcome when PMRT was delivered after BR, and this demonstrated that autologous reconstruction is associated with less morbidity in this setting (OR = 0.21; 95% CI, 0.1–0.4 [autologous vs. implant-based]). Delaying BR until after PMRT had no significant effect on outcome (OR = 0.87; 95% CI, 0.47–1.62 [delayed vs. immediate]). PMRT has a detrimental effect on BR outcome. These results suggest that where immediate reconstruction is undertaken with the necessity of PMRT, an autologous flap results in less morbidity when compared with implant-based reconstruction.

**Keywords** Post-mastectomy radiotherapy · Immediate and delayed breast reconstruction · Prosthetic breast reconstruction · Autologous breast reconstruction · Postoperative morbidity

## Introduction

Breast conservation surgery provides excellent loco-regional control with improved quality of life when compared with mastectomy [1]. However, many patients still require mastectomy as the optimum therapeutic cancer procedure, and many opt to undergo immediate breast reconstruction [2]. It is therefore essential that an appropriate strategy be proposed regarding the timing of reconstruction and postoperative radiotherapy. The enthusiasm for post-mastectomy breast reconstruction aims to achieve good functional aesthetic outcome and maintain their quality of life, without negatively affecting the prognosis or detection of cancer recurrence [3].

The Danish Breast Cancer Cooperative Group, 82b and 82c, trials in conjunction with findings from the Canadian trial collectively demonstrate that patients randomised to receive post-mastectomy radiation have a lower 10-year rate of local regional recurrence and an additional survival advantage associated with post-mastectomy radiotherapy [4, 5]. Based on these, and similar studies, clear guidelines are available regarding the indications for post-mastectomy radiation which are large tumour size, direct involvement of the skin, and four or more metastatic axillary lymph nodes [6–8]. However, despite reducing loco-regional recurrences and increasing disease-free survival [9], post-mastectomy radiotherapy may negatively affect reconstruction outcome.

As a consequence, several studies demonstrated that immediate breast reconstructions in irradiated patients are associated with the potential for significant postoperative morbidity [10, 11]. As a result, breast reconstruction may be delayed until the final pathological results are available from the mastectomy specimen and the indication for radiotherapy can be established.

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Immediate breast reconstruction without radiotherapy, offers enhanced aesthetic and safe oncological outcomes, is more cost-effective and provides a positive psychological effect [12–16]. Despite this, less than 20% of patients having a mastectomy have immediate breast reconstruction in the United States [2]. This may be because of patient choice or possibly apprehension on the part of the surgeon that radiotherapy maybe required postoperatively which potentially could compromise the reconstruction. Radiotherapy can cause unpredictable changes in all tissues and prosthetic materials [17]. It has a biphasic nature with the acute effects occurring over days to weeks and a delayed response, which can occur from months to years after completion of the therapy [18]. The acute phase usually involves acute inflammatory changes that may lead to desquamation or even necrosis of tissue [19]. The delayed phase involves atrophy, fibrosis and inhibition of normal wound-healing mechanisms [19]. Furthermore, opponents of immediate breast reconstruction suggest it may alter chest wall anatomy and therefore distort the geometrics of the radiation field design leading to under/overdosing the targeted and underlying tissues [20, 21]. However, Strålman et al. demonstrated a loco-regional recurrence rate of 6% in 100 patients who had a mastectomy with immediate (implant/autologous) reconstruction followed by radiotherapy with a mean follow up of  $108 \pm 26$  months. This suggests that there is no significant decrease in efficacy or delivery of radiation post-immediate implant or autologous reconstruction [22]. Furthermore, Huang et al. compared the incidence of local recurrence and distant metastasis of post-mastectomy radiotherapy for breast cancer patients with and without immediate TRAM flap reconstruction. They reported no statistical differences in the incidences of loco-regional recurrence or distant metastasis between the TRAM flap and the non-TRAM flap patients [23].

Therefore, the objective of this meta-analysis is to examine the published evidence whether patients requiring post-mastectomy radiotherapy should have an immediate or delayed reconstruction and whether a prosthesis or autologous reconstruction is associated with the optimum outcome in terms of postoperative morbidity.

## Methods

### Identification of studies

MEDLINE and EMBASE were searched by entering the following in the searching algorithm: breast reconstruction AND surgery OR radiation AND (clinical trial OR randomized controlled trial OR double-blind OR single-blind OR random OR randomized OR placebo **OR retrospective study OR prospective study**). English was set as a

language restriction. The latest search was performed on 1st January 2010. Two authors (M. Barry and M.R. Kell) independently examined the title and abstract of citations, the full texts of potentially eligible trials were obtained and disagreements were resolved by discussion.

### Eligibility criteria

All trials, whether randomized or non-randomized prospective or retrospective, that examined the effects of radiotherapy on immediate or delayed breast reconstruction using either a prosthesis or autologous tissue were eligible (latissimus dorsi—LD or transversus rectus abdominis muscle—TRAM). Case series or reports were not included. Studies where the data could not be accurately extracted were also excluded.

### Data extraction and outcomes

The following information regarding each eligible trial was recorded: authors' names, journal, patient numbers, timing and method of reconstruction, addition of radiotherapy and the postoperative complication rate. The primary end point of this meta-analysis was postoperative morbidity, including capsular contracture, fibrosis, fat necrosis and surgical site infections requiring removal of prosthesis/re-operation (see Tables 1, 2, 3 and 4).

### Statistical analysis

For postoperative complications in each study, the odds ratio (OR) of the simple proportions of events was estimated with its variance and 95% CI. Heterogeneity between the ORs for the same outcome between studies was assessed using the  $\chi^2$ -based  $Q$  statistic [24]. Data were then combined across studies by the use of general variance methods with fixed and random effects models [14]. Analyses were conducted using StatsDirect version 2.5.6 (StatsDirect Ltd, Chesire, United Kingdom) and SPSS version 12.0 (SPSS, Inc, Chicago, IL). All statistical tests were two-tailed.

## Results

### Eligible studies

About 20 potentially eligible studies were identified that examined the effects of radiotherapy on immediate or delayed breast reconstructions. Because of low numbers (e.g.  $n < 15$ ) or incomplete data set regarding postoperative morbidity, 9 studies were excluded from the meta-analysis. Of the 11 studies selected, 4 studies examined the

**Table 1** Postoperative complications in patients undergoing immediate breast reconstruction with an expander/implant (E/I) with or without post-mastectomy radiotherapy

Author	MOR	Patients	RT	CC (%)	Inf (%)	Nec (%)	Re-op (%)
Tallet et al. [25]	E/I	55	Yes	29	9	12.7	3.6
		22	No	0	9	0	4.5
Krueger et al. [26]	E/I	19	Yes	26	37	N/A	37
		62	No	10	19	N/A	8
Cordeiro et al. [27]	E/I	81	Yes	1.2	3.7	N/A	5
		75	No	3.7	0.9	N/A	0.7
Whitfield et al. [28]	E/I	41	Yes	19.5	N/A	N/A	N/A
		69	No	0	N/A	N/A	N/A

MOR method of reconstruction, RT radiotherapy, CC capsular contracture, Inf. infection, Nec necrosis, Re-op reoperation

**Table 2** Postoperative complications in patients undergoing post-mastectomy radiotherapy with either immediate implant or immediate autologous breast reconstruction

Author	N	MOR	RT	CC (%)	Inf (%)	Fib (%)	FN (%)	Re-op (%)
Anderson et al. [11]	35	Autol	Yes	0	0	5.7	17.2	0
	50	E/I	Yes	4	4	0	0	33
Jhaveri et al. [29]	23	Autol	Yes	0	0	N/A	N/A	0
	69	E/I	Yes	42.9	28.6	N/A	N/A	20.3
Wong et al. [10]	47	Autol	Yes	0	8.5	N/A	N/A	21.3
	15	E/I	Yes	40	13.3	N/A	N/A	66.6
Stralman et al. [22]	59	Autol	Yes	0	N/A	N/A	N/A	13.5
	82	E/I	Yes	17	N/A	N/A	N/A	34.1

N number of patients, MOR method of reconstruction, RT radiotherapy, CC capsular contracture, Inf infection, Fib fibrosis, FN fat necrosis, Re-op re-operation

**Table 3** Effect of radiotherapy on implant versus autologous breast reconstruction

Author	TOR	Patient no.	MOR	Radiotherapy	Complications (%)
Anderson et al. [11]	Immediate	35	Autolog.	Yes	0
	Immediate	50	Implant/Ex	Yes	5
Jhaveri et al. [29]	Immediate	23	Autolog.	Yes	8.7
	Immediate	69	Implant	Yes	55
Wong et al. [10]	Immediate	47	Autolog	Yes	9
	Immediate	15	Implant based	Yes	40
Stralman et al. [22]	Immediate	59	Autolog	Yes	13.5
	Immediate	82	Implant	Yes	34
Total	Immediate	164	Autolog	Yes	7.8
Total	Immediate	216	Implant	Yes	33.5

TOR timing of reconstruction, MOR method of reconstruction, Ex expander, Autolog autologous reconstruction

effects of RT on immediate BR using implant or expanders and 4 studies examined the effects of RT on immediate BR using either a prosthesis or autologous flap. Finally, 3 remaining studies evaluated the effects of RT on immediate versus delayed autologous BR (see Fig. 1).

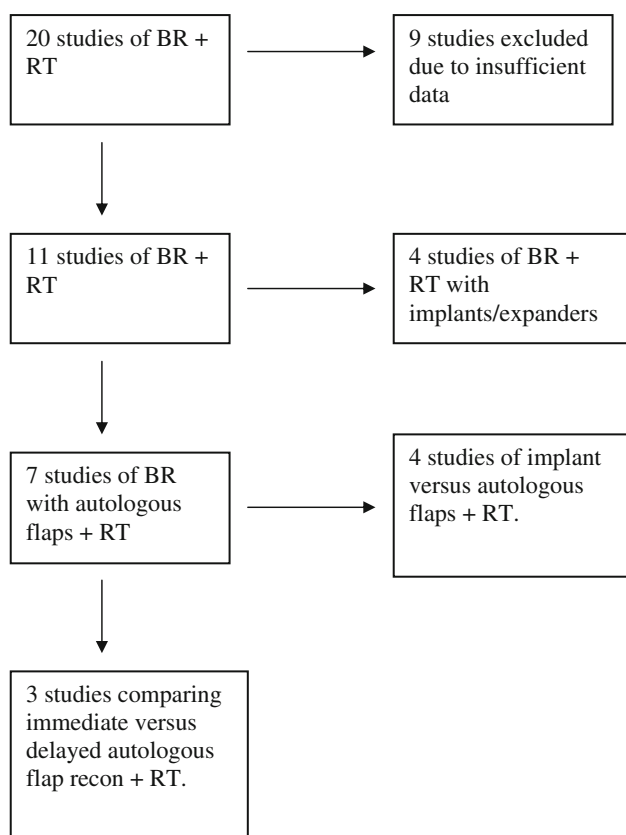
A total of 1,105 patients were identified from 11 selected studies [10, 11, 15, 22, 25–31]. These were subsequently

divided into three cohorts for subgroup analyses. The first group ( $n = 424$ ) were patients with immediate BR using a prosthesis alone with/without RT. The second subgroup ( $n = 380$ ) compared patients with immediate autologous BR versus prosthesis alone in the presence of RT. The last subgroup analysis ( $n = 301$ ) compared the effects of RT on immediate versus delayed autologous BR.

**Table 4** Postoperative complications in patients undergoing either immediate or delayed TRAM breast reconstruction with radiotherapy

Author	TOR	Patients	RT	Fib (%)	FN (%)	Inf (%)	Re-op (%)
Williams et al. [30]	Immed	19	Yes	10.5	15.8	5.3	N/A
	Delay	108	Yes	0	17.6	6.6	N/A
Tran et al. [31]	Immed	32	Yes	75	43.8	N/A	9.4
	Delay	70	Yes	0	8.6	N/A	0
Spear et al. [15]	Immed	34	Yes	N/A	23.7	5.3	0
	Delay	38	Yes	N/A	23.8	4.8	2.4

TOR type of reconstruction, RT radiotherapy, Fib fibrosis, FN fat necrosis, Inf infection, Re-op re-operation, Immed immediate reconstruction, Delay delayed reconstruction, N/A not available

**Fig. 1** Quorum diagram: Consort flow of study selection

#### Postoperative complications in BR in the presence of RT

Patients undergoing PMRT and immediate BR ( $n = 196$ ) are more likely to suffer morbidity when compared to patients not receiving PMRT ( $n = 229$ ) (OR = 4.2; 95% CI: 2.4–7.2 [no PMRT vs. PMRT]; see Fig. 2). Finally, reconstruction technique was examined when PMRT was delivered after BR and this demonstrated that autologous reconstruction is the superior reconstruction technique in terms of postoperative morbidity (OR = 0.20; 95% CI: 0.1–0.4 [autologous vs. implant-based]; see Fig. 3).

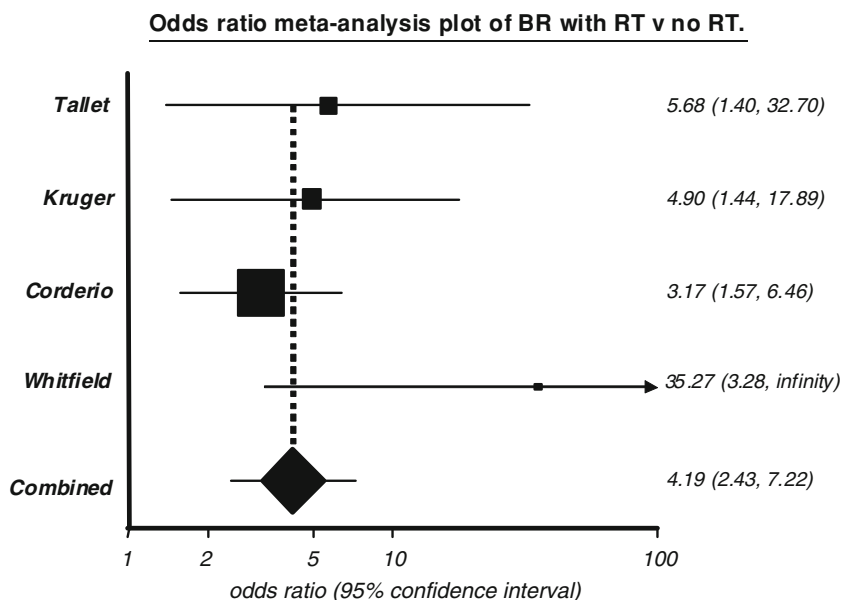
Postoperative morbidity was defined in terms of capsular contracture, infection, fat necrosis, fibrosis and the necessity to re-operate on the patient. The rates of these complications are displayed in Tables 1, 2 and 4. Interestingly, the effect of delaying BR until after PMRT had no significant effect on outcome (OR = 0.87; 95% CI: 0.47–1.62 [delayed vs. immediate]; see Fig. 4).

#### Discussion

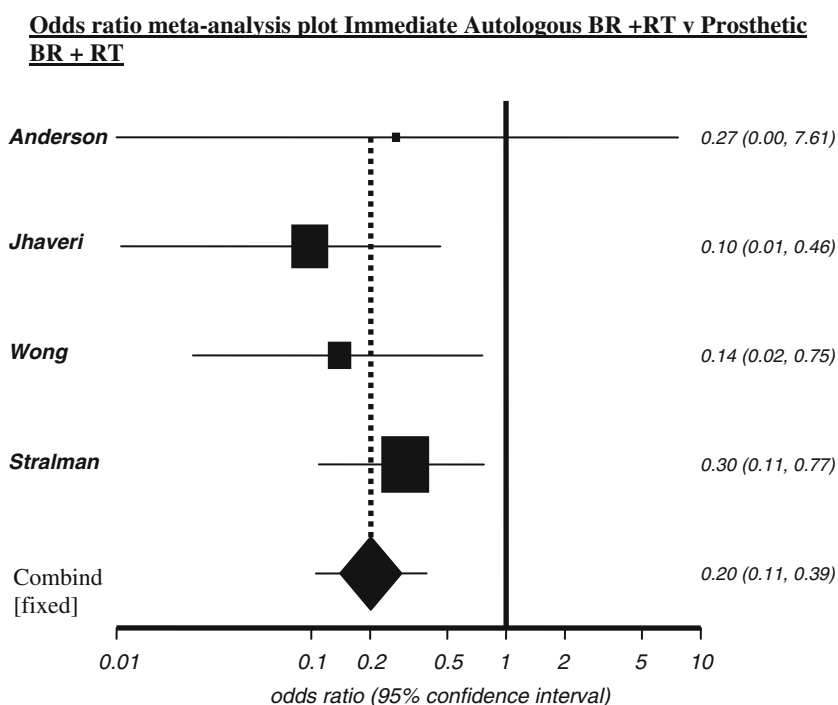
It is evident from the results that an immediate BR using a prosthesis only in the presence of RT is associated with an increased risk of postoperative complications (OR = 4.2; 95% CI: 2.4–7.2 [no PMRT vs. PMRT]). This is supported by the study of Aschermann et al. [32] who conducted a retrospective review of 104 patients (123 breasts) underwent mastectomy followed by implant breast reconstruction. They demonstrated that complications requiring prosthetic device removal or replacement, as well as total complications, were more frequent in breasts that received radiation than breasts that did not (18.5% vs. 4.2% for complications requiring prosthetic removal or replacement,  $P \leq 0.025$ , and 40.7% vs. 16.7% for total complications,  $P \leq 0.01$ ) [32]. On analysis of Tables 1 and 5, it is apparent that patients with immediate implant-based reconstructions receiving radiotherapy have significantly greater incidences of complications compared to those who did not receive radiotherapy.

Immediate breast reconstruction following a skin-sparing mastectomy has a number of advantages over the delayed reconstruction. First, it provides a more enhanced aesthetic result because of preservation of the infra-mammary fold, allowing a more natural appearance and there is also the option to adjust the position of the scar [14]. More importantly, for the patient, it provides enormous psychosocial benefits by restoring femininity and improving vitality, sexuality and quality of life [14]. In the absence of implants, immediate breast reconstruction has a very favourable morbidity profile even when exposed to

**Fig. 2** Meta-analysis of data comparing immediate BR using prosthesis only treated with RT



**Fig. 3** Meta-analysis of data comparing immediate autologous versus prosthetic BR in the presence of postoperative RT

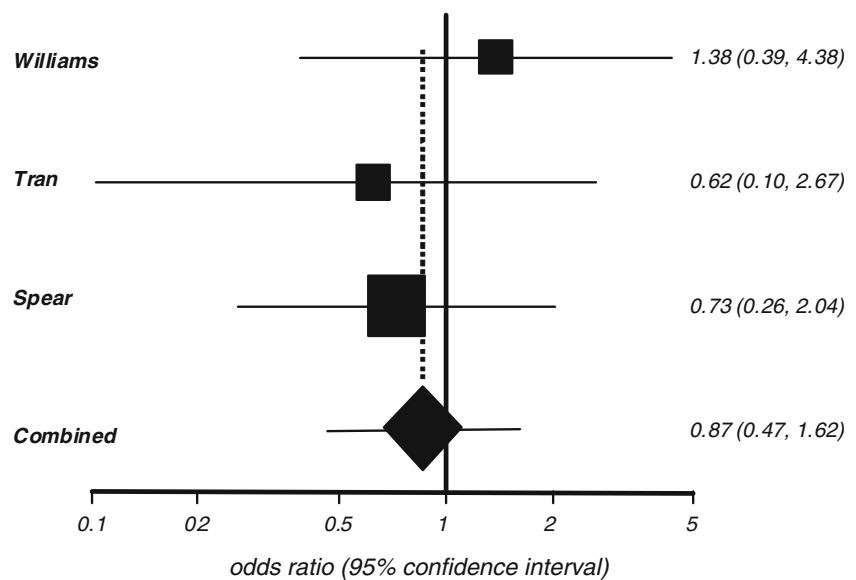


adjuvant radiotherapy [23]. Moreover, it is oncologically safe with an acceptable local recurrence rate [23]. Despite this, advocates of delayed breast reconstruction suggest that there are two main problems with immediate breast reconstruction in the presence of radiotherapy. First, radiation therapy can adversely affect the cosmetic outcome and cause increased postoperative complications [33]. Second, immediate breast reconstruction can impair the efficacy and delivery of radiotherapy [33]. Autologous

reconstructions have a more predictable response than implants to radiotherapy; however, the exact sequencing of this therapy is contentious. Kronowitz et al. [34] suggested the concept of the delayed-immediate breast reconstruction as a potential solution. This involves placing a tissue expander at the time of a skin-sparing mastectomy and waiting for the final pathological results of the specimen. If radiotherapy is not required, an immediate reconstruction is proposed and if radiotherapy is required, a delayed

**Fig. 4** Meta-analysis of immediate versus delayed autologous breast reconstruction with combined radiotherapy

**Odds ratio meta-analysis plot of Immediate BR + RT v Delayed BR + RT.**



**Table 5** Effect of radiotherapy on immediate implant/expander-based breast reconstruction

Author	TOR	Patient no.	MOR	Radiotherapy	Complications (%)
Tallet et al. [25]	Immediate	55	Implant	Yes	51
	Immediate	22	Implant	No	14
Krueger et al. [26]	Immediate	19	Implant/Ex	Yes	68
	Immediate	62	Implant/Ex	No	31
Cordeiro et al. [27]	Immediate	81	Implant/Ex	Yes	68
	Immediate	75	Implant/Ex	No	40
Whitfield et al. [28]	Immediate	41	Implant	Yes	19.5
	Immediate	69	Implant	No	0
Total	Immediate	196	Implant/Ex	Yes	51.6
Total	Immediate	228	Implant/Ex	No	21.2

TOR timing of reconstruction, MOR method of reconstruction, Ex expander, cc capsular contraction

reconstruction is advised. Unfortunately, this requires two operations that are associated with significant psychological and cost implications.

McKeown et al. [35] demonstrated that patient satisfaction with cosmetic outcome was similar between patients undergoing immediate and delayed reconstruction (autologous LD) plus radiotherapy. Interestingly, they also noted that most patients in retrospect preferred an immediate reconstruction [35]. In a prospective study by Thomson et al. [12] that assessed 73 women post-immediate implant-assisted LD or autologous LD reconstruction with or without radiotherapy, there was no difference between the groups in terms of overall cosmetic outcome as determined by the patients. When a panel of independent cosmetic assessors reviewed the photographic evidence at different intervals over a defined time period, they

concluded that although radiotherapy had an adverse effect on aesthetic outcome ( $P = 0.0002$ ), this was more obvious in the implant-assisted LD group [12].

Kroll and colleagues [36] reviewed 1,384 free-flap procedures performed for reconstruction of the breast or of head and neck defects. They assessed the effects of prior irradiation of the recipient site on the incidence of total flap loss which were more common in flaps transferred to previously irradiated sites [36]. It is evident from this study (Tables 4 and 6) that exposure of an autologous flap to radiotherapy increases the postoperative complication rates irrespective of whether an immediate or delayed reconstruction is performed (30.1% vs. 32.1%, respectively).

The potential limitations of this study are that patient selection criteria for either prosthetic-based or autologous BR were poorly defined and may have differed between

**Table 6** Effects of radiotherapy on immediate and delayed autologous flaps

Author	TOR	Patient no.	MOR	Radiotherapy	Complications (%)
Williams et al. [30]	Immediate	19	pTRAM	Yes	31
	Delayed	108	pTRAM	Yes	25
Tran et al. [31]	Immediate	32	fTRAM	Yes	9.4
	Delayed	70	fTRAM	Yes	14.3
Spear et al. [15]	Immediate	34	pTRAM	Yes	50
	Delayed	38	pTRAM	Yes	57.1
Total	Immediate	85	TRAM	Yes	30.1
Total	Delayed	216	TRAM	Yes	32.1

TOR timing of reconstruction, MOR method of reconstruction, *Radiotx* radiotherapy, *pTRAM* pedicled TRAM, *fTRAM* free TRAM

centres and time periods. There was also variation in the RT treatments used in terms of both dose and use of a boost. It is possible that the incidence of postoperative BR complication rates varies with the dose of RT used and this could not be assessed in our analysis.

Finally, in addition to selecting the appropriate timing of radiotherapy and reconstruction, appropriate patient selection is also paramount to consistently obtain successful outcomes. A BMI of less than 30 is associated with a better outcome in all reconstructive surgical procedures [37]. A history of smoking and diabetes is also poor prognostic indicators for myocutaneous flap viability [38]. Patient selection for reconstruction was not stated in many of the studies involved in this meta-analysis and therefore could not be included.

## Conclusion

Post-mastectomy radiation, irrespective of the method of reconstruction, increases the incidence of postoperative complications; however, this study has demonstrated that in this setting, an autologous flap offers a more favourable outcome in terms of morbidity than expander/implant reconstruction. There is a paucity of high-quality conclusive data regarding the correct sequencing of breast reconstruction and radiotherapy. The majority of studies involve small numbers of patients in single centres with retrospective analysis. Multicenter randomised controlled trials with longer follow-up times and better specified parameters are necessary to validate any future strategies regarding the optimum timing of radiotherapy and breast reconstruction. Unfortunately, these studies are difficult to perform, as it is difficult to ethically justify demanding that patients undergo an immediate versus a delayed reconstructive procedure because of a randomisation process. Therefore, in the absence of level-I evidence, the current data suggest that immediate breast reconstruction with PMRT may be undertaken though morbidity is higher with

either immediate or delayed technique. The timing and effect of radiotherapy on breast reconstruction must be discussed to ensure informed opinion and consent of the patient. The patients' expectations, preferences, motivations and their level of understanding should be explored to enhance postoperative satisfaction and quality of life [39].

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