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The Impact of Adjuvant Radiotherapy on Immediate Implant-based Breast Reconstruction Surgical and Satisfaction Outcomes: A Systematic Review and Meta-analysis

Ania Zugasti, MD*
Bernardo Hontanilla, MD, PhD†

Background: Adjuvant radiotherapy could be a necessary step in the oncological treatment for breast cancer. However, radiotherapy may have negative effects on implant-based immediate breast reconstruction. The aim of this study was to determine the impact of adjuvant radiation therapy on surgical results and patient-reported satisfaction outcomes in women undergoing immediate implant-based breast reconstruction.

Methods: A systematic search in PubMed was conducted on September 2019 and updated on April 2021. The risk of bias of the included studies was assessed using the Newcastle-Ottawa Quality Assessment Form for Observational Studies. RevMan 5 was used for statistical analysis. We obtained relative risks to determine the complication incidence and mean differences for 2-year BREAST-Q scores.

Results: Fourteen studies were included. A total of 11,958 implant-based immediate reconstructions were performed, 2311 received postmastectomy radiation therapy, and 9647 were considered as control group. Surgical complications, reoperation rates, and reconstruction failure were significantly higher among irradiated breasts. Significantly lower BREAST-Q scores were reported by irradiated women receiving radiotherapy.

Conclusions: This systematic review and meta-analysis combines reconstruction complication rates with aesthetic and patient-reported satisfaction outcomes. Adjuvant radiotherapy is consistently associated with greater complication rates and poorer aesthetic and satisfaction outcomes. The magnitude of association is significantly lower when the reconstruction is based on autologous tissues.
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INTRODUCTION

Even if early-stage cancer detection and screening methods have reduced breast cancer-related mortality, mastectomy and its surgical variants are still one of the main valuable tools in treating breast cancer patients.[1] Both a cancer diagnosis and oncological surgery have a great impact, physically and emotionally, on women's lives. Nearly half of the women receiving a mastectomy refer to having a negative body image and poor social and sexual well-being.[2] Breast reconstruction in its multiple shapes and forms greatly improves breast cancer patients' quality of life after mastectomy, as reflected on patient-reported questionnaires such as BREAST-Q or RAND-36.[3]

Immediate breast reconstruction offers multiple advantages, including a single operation, reduced overall costs, and early breast mound restoration, resulting in higher patient-reported aesthetic and psychological outcomes when compared to a delayed reconstruction.[4] A study by Razdan et al[5] assessing breast reconstruction trends during the 2010 decade showed a shift toward immediate breast reconstruction in women with postmastectomy radiotherapy (PMRT) indication; besides, they also found that implant-based techniques prevail over autologous reconstruction in the PMRT group. This, as well as other similar

*From the *Department of Plastic, Aesthetic and Reconstructive Surgery, Clinica Universidad de Navarra, Pamplona, Spain; and †Department of Plastic, Aesthetic and Reconstructive Surgery, Clinica Universidad de Navarra, Pamplona, Spain.*

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studies, shows a trend shift that questions one of the main axioms in plastic reconstructive surgery: radiotherapy (RT) as a relative contraindication when planning a reconstruction using exclusively alloplastic materials.

This study aimed to gather and assess the most recent evidence to try to quantify the impact that radiotherapy has on implant-based immediate breast reconstruction. This research included the possible correlation between the incidence of postreconstructive complications and aesthetic and patient-reported satisfaction outcomes. The hypothesis is that, even if radiation techniques have evolved, RT is still detrimental enough to keep considering it as, at least, a relative contraindication for exclusively implant-based reconstruction.

METHODS

This meta-analysis was conducted according to the *Cochrane Handbook for Systematic Reviews of Interventions*[6] and to the MOOSE guidelines, specifically designed for observational study–based systematic reviews.[7] Following PRISMA recommendations,[8] all decision-making criteria were set beforehand.

Eligibility Criteria

All trials reporting on immediate breast reconstruction based on the tissue expander/implant technique published 2014–2020 in Q1–Q2 medical journals were included. We excluded noncomparative studies and those where the comparison groups were other than PMRT versus non-PMRT. We excluded non-English, French, or Spanish-written articles. Animal model or experimental studies were excluded, as well as studies with a small sample size (N < 30).

Information Sources and Search Strategy

A systematic search in PubMed was first performed on September 27, 2019 and updated on April 3, 2021. The following search terms (medical subject headings) were used: "{[adjuvant radiotherapy] AND immediate AND ["mammaplasty" (MeSH Terms) OR BREAST RECONSTRUCTION (Text Word)]} AND breast implant." The last 5-year filter was applied.

Study Selection and Data Extraction

The following data were extracted from each article: author, publication year, type of cohort, age, number of breasts in each group (PMRT/non-PMRT), RT protocol and timing, and length of follow-up. The surgical outcomes were classified, as Apte et al[9] proposed, in early or late complications according to the timing of each event, less than 6 weeks postsurgery, or more than 6 weeks postoperative. Early complications included surgical site infection, mastectomy flap necrosis, seroma/hematoma, and implant extrusion. The assessed late complications include capsular contracture (III–IV), need for revision surgery, and reconstructive failure. Aesthetic and patient-reported satisfaction outcomes were assessed according to the BREAST-Q questionnaire on satisfaction with breast, satisfaction with the outcome, psychosocial well-being, and physical well-being.

Takeaways

Question: Is radiotherapy a good option when a breast implant/expander is used for mammary reconstruction?

Findings: Surgical complications, re-operation rates, and reconstruction failure were significantly higher among irradiated breasts. Significantly lower BREAST-Q scores were reported by women who received radiotherapy.

Meaning: Adjuvant radiotherapy is consistently associated with higher complication rates and poorer aesthetic and satisfaction outcomes.

Risk of Bias Assessment

The methodological quality of the included studies was assessed using the Newcastle-Ottawa Quality Assessment Form for Cohort Studies,[10] specifically designed for nonrandomized cohort studies. This evaluation form is based on three bias domains: selection, comparability, and outcome. On the outcome domain, for the follow-up length adequacy, we considered as acceptable 2 years or more of follow-up, since there is robust evidence that 74% of RT-associated complications occur during the first 3 years postimmediate reconstruction surgery, mainly in the first two.[11]

Statistical Analysis

All statistical analyses were performed using RevMan 5.4.1 (2020)[12] as statistical software. We obtained risk ratios (relative risk, RR) for surgical complication incidence and a mean difference for BREAST-Q scores. Data were pooled with fixed-effects meta-analysis to determine measures of association or mean differences, and 95% confidence intervals (CIs) for each comparison.

Heterogeneity was assessed using Cochran's Q test (considering heterogeneous results to have $P < 0.1$) and I^2 index. By default, fixed-effects meta-analysis was used when I^2 was less than 30%; if I^2 was 30% or more, random effects meta-analysis would have been used instead. Funnel plots were used to assess the risk of publication bias.

RESULTS

Study Characteristics

The search on PubMed resulted in 101 records (Fig. 1). After the removal of those meeting exclusion criteria, screening by title, abstract and full-text reading, nine studies were included for quantitative analysis. We also considered the bibliographical references of the included articles, which added 325 records. After the removal of duplicates and those meeting exclusion criteria, 147 articles were screened by title and abstract, 43 were considered for full-text assessment. Finally, 14 studies[11,13–25] were included in this review, and 29 records were excluded.[26–54] The main characteristics and results of the included studies are listed in Tables 1–3. Table 4 gathers the outcomes of the risk of bias assessment according to The Newcastle-Ottawa Scale.[10]

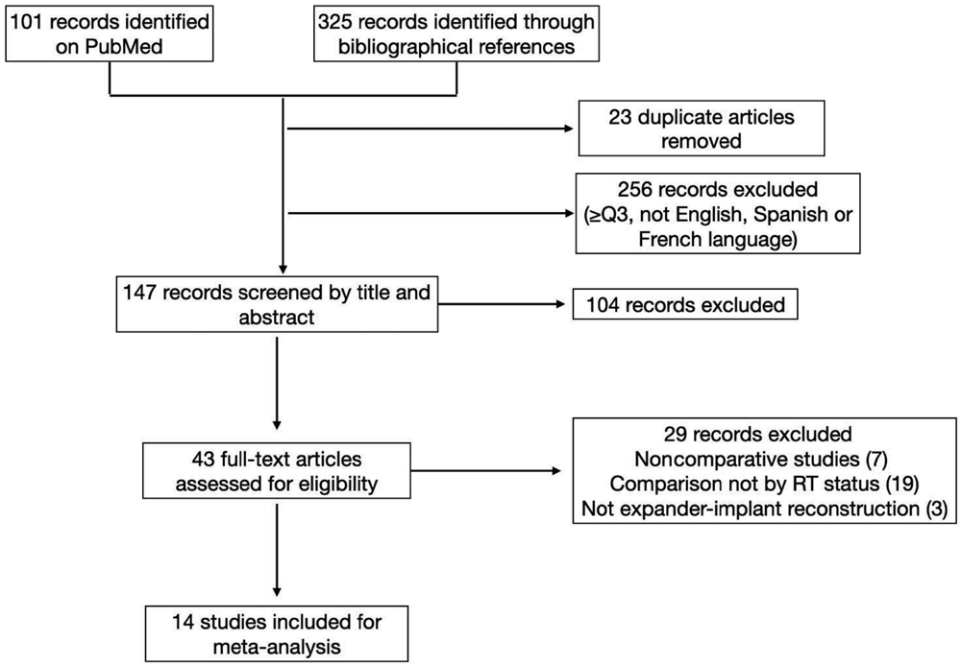

Fig. 1. Study selection flow chart.

Of a maximum of nine points, one study scored nine, 10 scored eight, and three scored seven points. As previously mentioned, follow-up of 2 years or more was considered adequate. Since two studies did not report the length of the follow-up they did not score for this item. All of the studies scored positively for the selection of the nonexposed cohort, ascertainment of the exposure, absence of the event of interest before the exposition, and assessment of the outcome since every complication or treatment required was recorded by healthcare professionals. Since two of the studies reported missing patients' responses during the follow-up questionnaires, although they statistically adjusted and managed it, we decided to be conservative and did not give points for this item.

Early Complications

Surgical Site Infection

Nine studies assessed surgical site infection, yielding 4837 reconstruction procedures and 150/1017 cases in the PMRT group and 198/3820 in the non-RT group. PMRT was significantly associated with higher infection rates, resulting in a 2.44 RR (95% CI 1.97, 3.01; $P < 0.00001$). There was no evidence of significant heterogeneity (Chi square = 5.61; $P = 0.69$; $I^2 = 0\%$) (Fig. 2).

Mastectomy Skin Flap Necrosis

Mastectomy flap necrosis was assessed in eight of the selected studies. PMRT was significantly associated with a higher risk of skin necrosis (RR = 1.62; 95% CI = 1.27, 2.08). There was no evidence of significant heterogeneity (Chi square = 7.02; $P = 0.43$; $I^2 = 0\%$) (Fig. 3).

Serohematoma

One study assessed the combined incidence of serohematoma, and eight reported the incidence of seroma and hematoma incidence. These results were managed jointly. The incidence of serohematoma was slightly higher among irradiated breasts. However, there was no significant difference between the two groups for this comparison (RR = 1.1; 95% CI = 0.85, 1.43). There was no evidence of significant heterogeneity (Chi square = 9.6; $P = 0.29$; $I^2 = 17\%$) (Fig. 4).

Implant Extrusion or Exposure

Five of the included studies reported data regarding implant extrusion. There was a higher extrusion rate in the PMRT group (5.95% versus 2.01%), RR of 3.44 (95% CI 2.18, 5.43). There was some evidence of not significant heterogeneity (Chi square = 5.59; $P = 0.23$; $I^2 = 28\%$) (Fig. 5).

Late Complications

Capsular Contracture (III–IV)

Baker scale grade III–IV capsular contracture[55] incidence was assessed in seven studies. There was a significantly higher incidence of capsular contracture in the PMRT group (24.31% versus 4.42%), with an RR of 5.47 and 95% CI of 3.34, 8.97. Since there was evidence of significant heterogeneity, random effects analysis was used for this comparison (Tau2 = 0.16; Chi square = 12.76; $P = 0.05$; $I^2 = 53\%$) (Fig. 6).

Revision Surgery

Revision surgery rates comprehend the unplanned return to the operating room due to acute complications or the consequences of previous events. The number of reoperations was significantly higher in the PMRT group (34.72%) versus non-RT group (10.70%): RR = 1.64; 95% CI = 1.17, 2.31. There was no evidence of significant heterogeneity (Chi square = 1.01; $P = 0.60$; $I^2 = 0\%$) (Fig. 7).

Table 1. Characteristics of the Studies Included in the Systematic Review

Study	Year	Type of Cohort	Age (Yrs)	Non-RT	PMRT	Reconstruction Type*	RT Protocol	RT Timing	Follow-up (Yrs)
Cordeiro et al[13]	2014	Prospective 1998–2010	46.9	1814	319	Tissue expander/ implant	6 MV photons	RT on definitive implant, 4 wks after exchenge	4.65
Sbitany et al[14]	2014	Prospective 2006–2012	45.4	727	113	Tissue expander/ implant	NR	NR	1.94
Chen et al[15]	2015	Retrospective 2007–2013	50.27 54.88	30	38 8	Tissue expander/ implant	NR	After complete expansion, before the exchange (38) Before tissue expander placement (8)	NR
Cordeiro et al[16]	2015	Prospective 2003–2012	46.7	1486	94 210	Tissue expander/ implant Direct-to-implant	6 MV/15 MV	6 MV over implant, 15 MV over expander, depending on chemotherapy protocol	3.57
Reish et al[17]	2015	Retrospective 2007–2012	46.95	517	45	Tissue expander/ implant or direct-to-implant depending on skin flap health	NR	Before/after tissue expander exchange depending on urgency or oncologist/surgeon preference	1.8
Seth et al[18]	2015	Retrospective 1999–2008	48.6 50.9	879 51	248 23	Immediate tissue expander/implant Delayed tissue expander/implant	NR	During expansion	NR
Muresan et al[19]	2017	Retrospective 2010–2013	48.9	125	533	Tissue expander/ implant or direct-to-implant	50–60 Gy, higher mean dose in supine vs prone position during RT	NR	2.11
Elswick et al[20]	2018	Retrospective 2012–2016	48	39	54	Tissue expander/ implant	50 Gy, 25 fractions	After complete expansion, before the exchange	2.3
Jagsi et al[21]	2018	Prospective 2012–2015	NR	1218 407	386 236	Tissue expander/ implant autologous	NR	NR	2
Smith et al[22]	2019	Prospective 2025–2017	49	42	51	Tissue expander/ implant	50 Gy in 25 fractions or 40 Gy in 15 fractions (hypofractionated group)	6 wks after tissue expander location or 3–4 wks after chemotherapy	1.33
Zhang et al[23]	2019	Retrospective 2001–2015	38†	342 331	52 107	Tissue expander/ implant autologous	NR	NR	4.8†
Lam et al[11]	2019	Retrospective 1998–2010	47.01	324	118	Tissue expander/ implant	50 Gy, 25 fractions	Over tissue expander after full expansion	3.52
Naoum et al[24]	2019	Retrospective 1997–2017	49.3	603 462 220	236 171 122	Tissue expander/ implant direct-to-implant Autologous	NR	During expansion or after tissue expander exchange	5.8†
Olinger et al[25]	2020	Prospective 2012–2015	NR	1093 88	316 13	Tissue expander/ implant direct-to-implant	NR	NR	2

*All expander-implant–based reconstructions are immediate unless otherwise specified.
†Median.
NR, not reported.

Reconstructive Failure

Reconstructive failure includes reconstruction failure, implant loss, or a reconstruction technique change to an autologous reconstruction. PMRT was associated with a significantly higher rate of reconstructive failure (RR = 3.32; 95% CI = 2.82, 3.91). There was no evidence of significant heterogeneity (Chi square = 15.19; $P = 0.17$; $I^2 = 28\%$) (Fig. 8).

Aesthetic and Satisfaction Results

Four of the included studies include data regarding satisfaction with breasts at 2-years postreconstruction. Since Lam et al[11] measured satisfaction in ordinal categories (poor, fair, good, excellent) and Cordeiro et al[16] measured the BREAST-Q score using the adjusted median instead of the mean± SD, those studies could not be included for the quantitative analysis.

Satisfaction with Breast

The difference between the two groups is statistically significant ($P < 0.00001$) in favor of the non-RT group. The mean difference is 11.41 (95% CI = −13.88, −8.95). There is no evidence of significant heterogeneity (Chi square = 0.03; $P = 0.87$; $I^2 = 0\%$) (Fig. 9).

Satisfaction with Outcome

Satisfaction with outcome was assessed in two studies. There was statistically significant difference favoring non

Table 2. Early and Late Complication Incidence

Study	N	Surgical Site Infection	Mastectomy Flap Necrosis	Seroma/ Hematoma	Extrusion/ Exposure	Capsular Contracture III–IV	Revision Surgery	Reconstructive Failure
Cordeiro et al[13]	PMRT: 319				29 (9.1%)	147 (46.1%)		6 (1.9%)
	Non-RT: 1814				9 (0.5%)	116 (6.4%)		4 (0.2%)
	Total: 2133							
Sbitany et al[14]	PMRT: 113	25 (22.1%)	17 (15%)	10 (8.8%)	12 (10.6%)			20 (17.7%)
	Non-RT: 727	53 (7.3)	39 (5.3%)	56 (7.7%)	33 (4.5%)			37 (5.1%)
	Total: 840							
Chen et al[15]	PMRT: 38	17 (44.7%)	3 (7.9%)	5 (13.2%)	3 (7.9%)	11 (28.9%)	26 (68.4%)	
	Non-RT: 30	8 (26.6%)	3 (10.0%)	6 (20.0%)	1 (3.3%)	2 (6.6%)	14 (46.6%)	
	Total: 68							
Cordeiro et al[16]	PMRT: 210							26 (12.4%)
	Non-RT: 1486							68 (4.6%)
	Total: 1696							
Reish et al[17]	PMRT: 45	3 (6.7%)	3 (6.7%)	1 (2.2%)		7 (15.6%)		4 (8.9%)
	Non-RT: 517	15 (2.9%)	28 (5.4%)	18 (3.5%)		12 (2.3%)		5 (0.9%)
	Total: 562							
Seth et al[18]	PMRT: 248	20 (8.1%)	27 (10.9%)	16 (6.5%)	9 (3.6%)			35 (14.1%)
	Non-RT: 879	36 (4.1%)	67 (7.7%)	51 (5.8%)	8 (0.9%)			53 (6.0%)
	Total: 1127							
Muresan et al[19]	PMRT: 125	19 (15.2%)	10 (8%)	6 (4.8%)	12 (9.6%)	8 (6.4%)		11 (8.8%)
	Non-RT: 533	36 (6.8%)	38 (7.1%)	15 (2.8%)	13 (2.4%)	0		4 (0.8%)
	Total: 658							
Elswick et al[20]	PMRT: 54	10 (18.5%)	1 (1.9%)	4 (7.4%)	1 (1.9%)	1 (1.9%)	16 (29.6%)	6 (11.1%)
	Non-RT: 39	3 (7.7%)	1 (2.6%)	3 (7.7%)	0	0	7 (17.9%)	1 (2.6%)
	Total: 93							
Jagsi et al[21]	PMRT: 386							47 (12.2%)
	Non-RT: 1218							43 (3.5%)
	Total: 1604							
Smith et al[22]	PMRT: 51	14 (27.5%)	2 (3.9%)	5 (9.8%)		1 (1.9%)		8 (15.7%)
	Non-RT: 42	1 (2.4%)	1 (2.4%)	1 (2.4%)		0		2 (4.8%)
	Total: 93							
Zhang et al[23]	PMRT: 52						8 (15.4%)	
	Non-RT: 342						23 (6.7%)	
	Total: 394							
Lam et al[11]	PMRT: 118	5 /107 (4.7%)		16/107 (14.9%)				20/100 (20%)
	Non-RT: 324	11/450 (2.4%)		89/450 (19.7%)				24/316 (7.6%)
	Total: 442							
Naoum et al[24]	PMRT: 236	37 (15.7%)	21 (8.9%)	12 (5.1%)	16 (6.8%)	36 (15.3%)		21 (9.1%)
	Non-RT: 603	35 (5.8%)	31 (5.1%)	13 (2.2%)	4 (0.7%)	28 (4.6%)		17 (3.0%)
	Total: 839							
Olinger et al[25]	PMRT: 316							56 (17.0%)
	Non-RT: 1093							48 (4.1%)
	Total: 1409							

irradiated breasts ($P < 0.00001$). The mean difference is 6.91 (95% CI = –9.47, –4.35). There was no evidence of significant heterogeneity (Chi square = 0.14; $P = 0.71$; $I^2 = 0\%$] (Fig. 10).

Risk of Publication Bias

Funnel plots for different comparisons were obtained for the risk of publication bias assessment (Fig. 11).

DISCUSSION

This systematic review and meta-analysis aimed to quantify the impact of adjuvant RT on implant-based breast reconstruction. This review showed consistent results regarding previous research[33,56,57] since PMRT is significantly associated with a higher incidence of postoperative complications, higher reoperation and reconstructive failure rates, and poorer cosmetic and satisfaction outcomes.

Table 3. Two-year BREAST-Q Scores

Study		Satisfaction with Breast	Satisfaction with Outcome	Psychosocial Well-being	Physical Well-being
Cordeiro et al[16] *	PMRT	56.2	68.4	71.1	72.5
	Non-RT	64.1	73.5	76.4	78.5
Jagsi et al[21] †	PMRT	54.2 ± 19	64.8 ± 22	66.4 ± 19.2	71.3 ± 14.1
	Non-RT	65.4 ± 17.5	71.3 ± 21.4	75.2 ± 18.8	77.6 ±14.1
Olinger et al[25] †	PMRT	54.5 ± 18.4	64.3 ± 21.5		
	Non-RT	66.1 ± 17.3	71.8 ± 21		

*Adjusted median.
†Mean ± SD.

Table 4. Newcastle-Ottawa Quality Assessment Form for Cohort Studies

	Selection*				Comparability†	Outcome*			
Study	Representativeness of the Exposed Cohort	Selection of the Nonexposed Cohort	Ascertainment of Exposure	Outcome of Interest Not Present at Start of the Study	Comparability of Cohorts on the Basis of the Design or Analysis	Assessment of Outcome	Follow-up Long Enough	Adequacy of Follow-up	Total Score
Cordeiro et al[13]	1	1	1	1	1	1	1	1	8
Sbitany et al[14]	1	1	1	1	2	1	0	1	8
Chen et al[15]	1	1	1	1	2	1	0	1	8
Cordeiro et al[16]	1	1	1	1	1	1	1	1	8
Reish et al[17]	1	1	1	1	2	1	0	1	8
Seth et al[18]	1	1	1	1	1	1	0	1	7
Muresan et al[19]	1	1	1	1	1	1	1	1	8
Elswick et al[20]	1	1	1	1	2	1	1	1	9
Jagsi et al[21]	1	1	1	1	2	1	1	0	8
Smith et al[22]	1	1	1	1	1	1	0	1	7
Zhang et al[23]	1	1	1	1	1	1	1	1	8
Lam et al[11]	1	1	1	1	1	1	1	1	8
Naoum et al[24]	0	1	1	1	1	1	1	1	7
Olinger et al[25]	1	1	1	1	2	1	1	0	8

*Maximum score is 2
†Maximum score is 1

Capsular contracture was the most frequent complication in irradiated breasts. Grade III–IV capsular contractures were considered clinically significant. Capsular contracture and, indirectly PMRT, do have a great impact on breast reconstruction results since they may require additional surgeries for correction or may increase the risk of reconstruction failure. Moreover, capsular contracture plays a great role in conditioning poorer cosmetic outcomes and lower patient satisfaction scores on the PMRT group. These results showing the association between PMRT and capsular contracture, besides obeying biological plausibility, are consistent with previous works.[58,59]

PMRT is also significantly associated with higher major complication incidence, and since major complications are defined as those requiring surgical intervention as part of the treatment, is necessarily associated with higher reoperation rates. Even if Chen et al[15] also described this association between PMRT and higher complication rates, it was not statistically significant. This could be due to smaller sample size and lower statistical power compared to the rest of the included studies, in which this association was statistically significant. These results are, therefore, consistent with previously published literature.[60–62] This increase of the RT attributable risk is statistically significant on implant-based

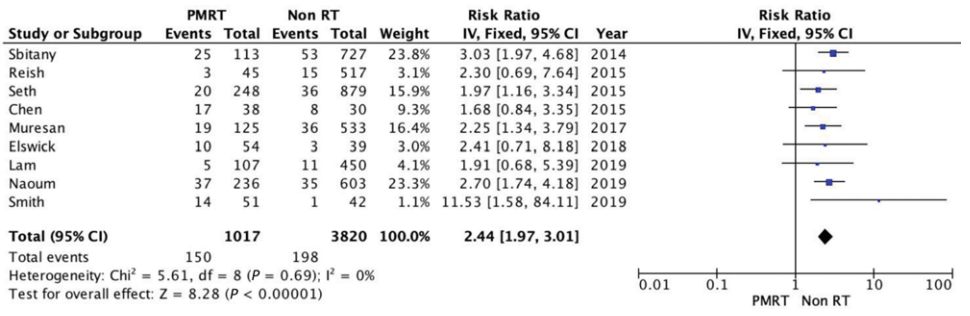

Fig. 2. Forest plot for surgical site infections.

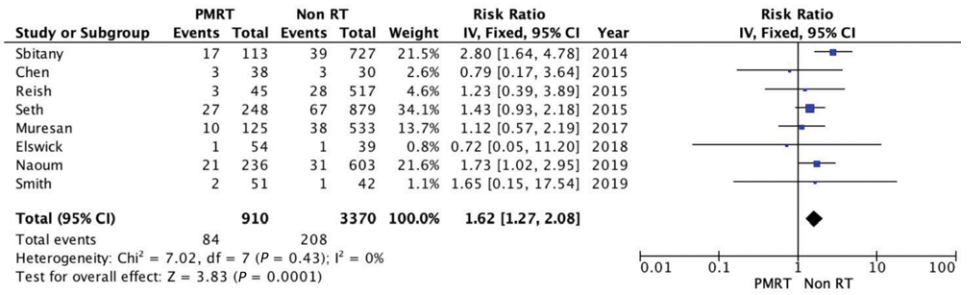

Fig. 3. Forest plot for mastectomy flap necrosis.

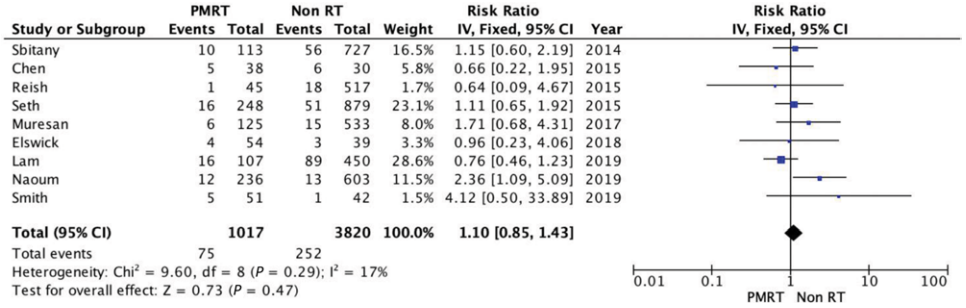

Fig. 4. Forest plot for serohematoma.

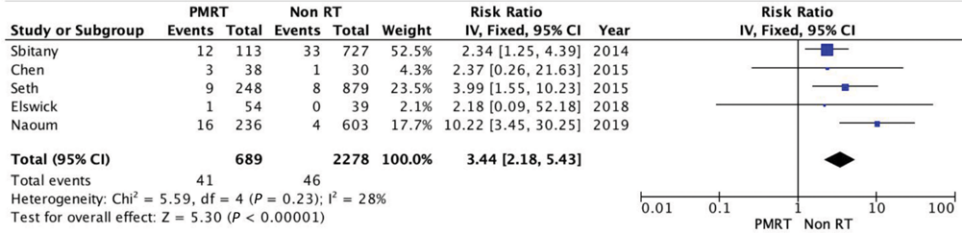

Fig. 5. Forest plot for implant extrusion or exposure.

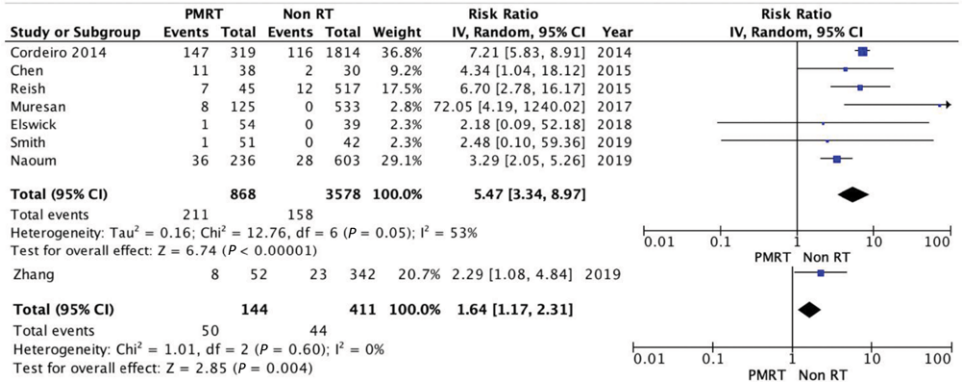

Fig. 6. Forest plot for capsular contracture (III–IV).

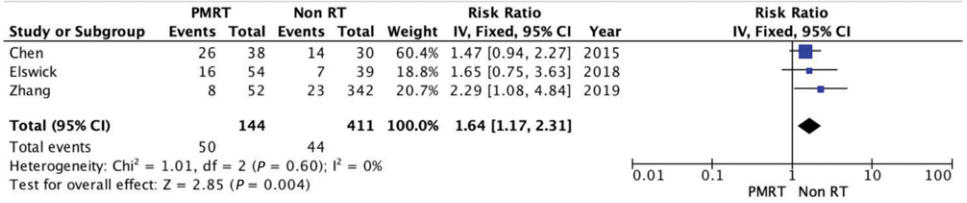

Fig. 7. Forest plot for reintervention.

immediate reconstructions but is not as pronounced on reconstruction based on autologous tissues. Zhang et al[23] reported a rate of unplanned return to OR or the need for secondary surgeries for complication management. The reported rate was 10.3% on immediate autologous reconstruction for the PMRT group and 6.6% in the autologous control group; for implant-based reconstruction, the reoperation rate was 15.4% versus 6.7% in PMRT and control group, respectively. The incidence of major complications requiring surgical intervention is similar for both, alloplastic and autologous reconstruction in the absence of radiotherapy; therefore, the greater increase in major complication incidence and need for surgical revision could be attributed to the damaging effect of adjuvant RT. These higher rates of reoperation and secondary surgeries in women receiving adjuvant RT are consistent with the available evidence. Unukovych et al[63] described a significant association between PMRT and a major need for surgical management of complications on implant-based immediate reconstructions with an OR of 5.2 (95% CI 1.9, 14.6, $P = 0.002$).

Regarding implant loss or reconstructive failure, the rate seems to be slightly lower compared to previous articles.

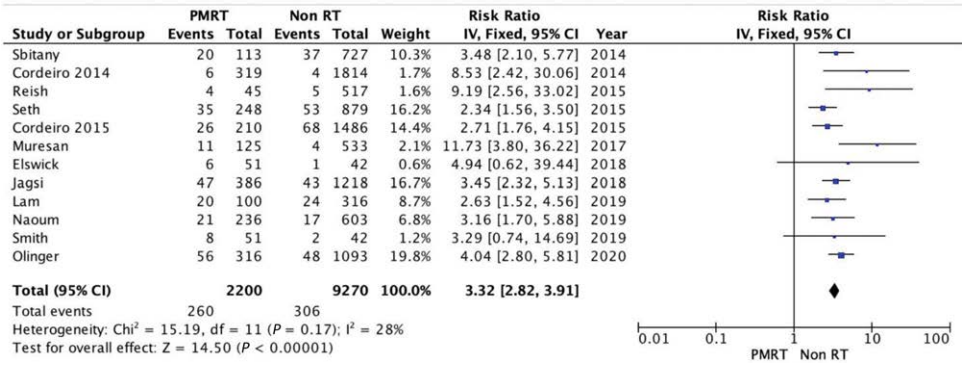

Fig. 8. Forest plot for reconstructive failure.

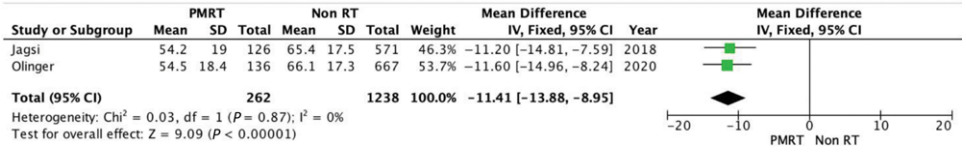

Fig. 9. Forest plot for satisfaction with breasts at 2 years.

Fig. 10. Forest plot for satisfaction with outcomes at 2 years.

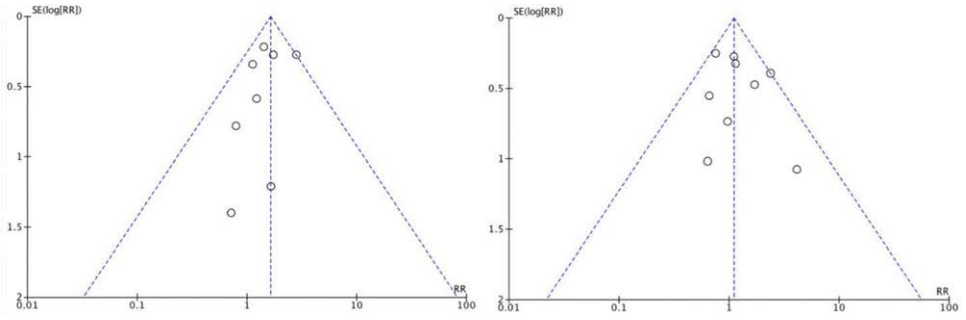

Fig. 11. Funnel plot for risk of publication bias. Left, necrosi; right, serohematoma.

This may be due to sophistication or improvement in radiotherapy techniques and a less aggressive surgical management of the mastectomy flap.[44] Some authors suggest that better coverage of the implant may ensure reconstruction viability even if RT is applied. Nonetheless, a study assessing the use of acellular dermal matrix for implant coverage in irradiated immediate breast reconstruction showed no difference between acellular dermal matrix and the control group regarding complication rates.[64] Several other factors may condition reconstruction outcomes or complication incidence and are seldom taken into account extensively in the reviewed literature. Age, body mass index, smoking status, and medical comorbidities such as hypertension or diabetes mellitus are considered independent risk factors for reconstruction-associated complications.[65–67] A better understanding of these factors and the interaction between them would help to better determine the real and individualized risk of poorer reconstruction outcomes in each case.

The damaging effect of RT on the irradiated tissues and their vascular supply may compromise the feasibility, and surgical and aesthetic outcomes of the immediate breast reconstruction.[33,68,69] PMRT is associated with

poorer aesthetic outcomes when the immediate reconstruction is based on alloplastic materials but not when it is based on autologous techniques.[21,25] Autologous reconstruction is also susceptible to RT-induced complications such as fat necrosis, atrophy, or fibrosis.[33,70,71] However, RT attributable complication incidence is significantly lower with significantly better satisfaction and cosmetic outcomes.[72] The differences found in the patient-reported BREAST-Q for satisfaction with breast and outcome at 2 years from the reconstruction increase in the long-term, resulting in progressively lower scores with the passage of time.[73] Therefore, the patient's life expectancy should be added to the previously mentioned list of factors that should be taken into account when assessing the most suitable reconstruction option for each woman.

The reconstruction cases assessed in this review were tissue expander/implant-based. However, the radiotherapy protocol and timing were different for each institution meaning that the stage of the reconstruction in which RT was applied may vary. Nonetheless, the results and associations found are consistent even with studies in which the RT was applied on the definitive implant.[59] These poor outcomes occur when RT is applied on the tissue expander as much as on a definitive implant, meaning that the consequences of the RT on the irradiated breasts are consistently deleterious in every implant-based immediate reconstruction technique.

This systematic review has certain limitations. As an inherent limitation of systematic reviews and meta-analysis, the quality inferences made cannot exceed the quality of the studies they are based on. Hence, the methodological quality of the studies was confirmed based on the satisfactory scores in the Newcastle-Ottawa Quality Assessment Form for Cohort Studies.[10] Hence, the strong association found in this review should not be dismissed alluding to the retrospective nature of the cohort studies that it is based on. Although the heterogeneity statistically assessed using Cochran's Q test and I^2 index was not significant, there was some kind of variability between studies that could not be extensively assessed. The variability between the published articles and previous research comprises different factors such as the type of mastectomy, RT timing and dosage of PMRT, immediate reconstruction technique (tissue expander/implant versus direct-to-implant), systemic chemotherapy, or patient-dependent factors or comorbidities. A better description and quantification of these factors would result in more rigorous research that would bring up more accurate conclusions. Even if randomized controlled trials could be carried out to solve the inherent biases when assessing retrospective cohorts and to verify these findings, these results are consistent with previous reviews and articles.[56,57,74]

CONCLUSIONS

This meta-analysis showed a significant association between adjuvant RT and a higher incidence of early complications (infection, necrosis, and implant extrusion) and late complications (capsular contracture and reoperation) with higher reconstructive failure or reconversion to autologous reconstruction rates when applied over implant-based immediate reconstruction. Moreover, PMRT was associated with poorer cosmetic outcomes and lower patient-reported satisfaction scores, both mid- and long-term. These results are consistent with previous reviews and articles. Furthermore, investigation of factors leading to poorer results would be needed to better understand the risk–benefit balance in each case for individualized counseling on which reconstructive method would most benefit each woman, short- and long-term.

Bernardo Hontanilla, MD, PhD
Department of Plastic, Aesthetic and Reconstructive Surgery
Clinica Universidad de Navarra
Pamplona, Spain
E-mail: bhontanill@unav.es

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