Ann Surg Oncol (2022) 29:3785–3797
https://doi.org/10.1245/s10434-022-11350-5

Annals of
SURGICAL ONCOLOGY
OFFICIAL JOURNAL OF THE SOCIETY OF SURGICAL ONCOLOGY

ORIGINAL ARTICLE – BREAST ONCOLOGY

Impact of Quilting Sutures on Surgical Outcomes After Mastectomy: A Systematic Review and Meta-Analysis

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ABSTRACT

Background. Seroma after mastectomy and/or axillary lymph node dissection (ALND) is among the most common issue surgeons have to face in the early postoperative management of breast cancer. Using quilting sutures (QS) to aid in tissue approximation and decrease dead space is proposed as a simple technique to reduce seroma rate. We aimed to perform a systematic review, and analyse, in a meta-analytical model, the role of QS in improving wound outcomes and decrease volume, duration of drainage, and length of stay in hospital.

Methods. The study was registered with PROSPERO. A systematic search of the PubMed, EMBASE, and SCOPUS databases was performed for all comparative studies examining surgical outcomes in patients who underwent QS versus conventional closure (CC) after mastectomy ± ALND.

Results. Twenty-one studies with a total of 3473 patients (1736 in the study group and 1737 in the control group) were included based on the selection criteria. The study group showed significantly lower rates of seroma ($p < 0.00001$), total volume of drainage ($p < 0.0001$), days to drain removal ($p < 0.00001$), and length of stay ($p < 0.00001$) compared with the control group, while wound complication rates (surgical site infection, flap necrosis, hematoma, skin dimpling) were comparable between the two groups.

Conclusions. QS are a reliable intraoperative technique that decrease seroma formation, volume of postoperative drainage, duration of drainage and length of hospital stay, and should be considered in mastectomies with or without ALND.

First Received: 1 December 2021
Accepted: 5 January 2022;
Published Online: 1 February 2022

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Fluid accumulation after mastectomy and/or axillary lymph node dissection (ALND) is among the most common issues surgeons have to face in the early postoperative management and a major factor contributing to the significant financial burden of breast care management.[1–5] When the collection of serous fluid becomes clinically evident and symptomatic, it is defined as a seroma.[6] Seroma is the most common complication after mastectomy, with an incidence rate of up to 60%, and a significant cause of perioperative morbidity and patient discomfort.[3–7] Moreover, the presence of seroma increases wound complication rates and hospital stay, thus delaying recovery and the initiation of adjuvant therapy.[8] Axillary dissection,[9] obesity,[10] neoadjuvant therapy,[11] smoking,[12] and electrocautery use[13] have been proposed as risk factors for seroma formation and longer duration of drainage. Conventionally, mastectomy flaps are closed by approximating the edges, while fluid accumulation in the dead space, beneath the skin flaps, and in the axilla, is reduced through closed-suction drainage. Apart from suction drainage, other techniques have been described to reduce dead space, including quilting sutures (QS) of the skin flaps to the underlying pectoralis fascia, quilting of the axillary space, tissue adhesives,[14,15] gentamicin-collagen sponges,[16] etc. Using QS to aid in tissue approximation and decrease dead space is proposed as a simple and cheap intraoperative technique to reduce the seroma rate, thus improving wound outcomes and decreasing hospital stay and costs of care. We aimed to perform a systematic review, and analyse, in a meta-analytical model, the role of QS in improving wound outcomes and decrease the volume of drainage, duration of drain removal, and length of stay in hospital.

MATERIALS AND METHODS

Literature Search and Study Selection

The study was registered with PROSPERO (International Prospective Register of Systematic Reviews), and had a study ID of CRD42021255268. A systematic search of the PubMed, EMBASE, and SCOPUS databases was performed for all comparative studies examining surgical outcomes in patients who underwent QS versus conventional closure (CC) after mastectomy with or without ALND. The following search algorithm was used: (quilting) OR (closure) OR (suture) AND (mastectomy) AND (seroma). Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were used as the search protocol and the PRISMA checklist was followed to conduct the methodology[17] (Fig. 1). Inclusion criteria were used according to the Problem, Intervention, Comparison and Outcome (PICO) formula. The latest search was performed on 3 April 2021. Two authors (SM and CC) assessed the titles and abstracts of studies found in the search and the full texts of potentially eligible trials were reviewed. Disagreements were resolved by consensus-based discussion. The Newcastle–Ottawa scale (Table 1) and the ROBINS-I tool (Fig. 2) were used to quantify the quality of eligible studies. The references of full texts reviewed were further screened for additional eligible studies. The corresponding author was contacted to clarify data extraction if additional information was necessary.

Eligibility Criteria

Studies written in English that included comparative surgical data between quilting versus no quilting sutures (CC with or without drainage) post mastectomy ± ALND were assessed for eligibility. The primary endpoints were seroma formation and total volume of drainage, while secondary endpoints included patient characteristics, wound complications, and early postoperative outcomes. Long-term and oncological outcomes were not recorded. Patients with immediate breast reconstruction were excluded as were male patients and studies including only ALND, without mastectomy. Studies without comparative data or with comparison between QS and tissue adhesives were also not included, along with studies in which QS were not the only intervention in the study group (SG).

Data Extraction and Outcomes

For each eligible study, the following data were recorded: author names, journal, year of publication, study type, total number of patients and number of patients included in each group, skin flaps quilting technique, axillary quilting, number of drains used in each group, mean age, mean body mass index (BMI), smoking status, and lymph node yield. The type of procedure was recorded and was defined as modified radical mastectomy (MRM), mastectomy only, ALND, sentinel lymph node biopsy (SLNB), and lumpectomy. For each study, the outcomes of interest were extracted and grouped into three main categories, which were further analyzed: (1) risk factors for seroma formation (BMI, neoadjuvant therapy, operative time, lymph node yield); (2) drainage outcomes (seroma, total volume of drained fluid, days to drain removal, length of stay); and (3) wound outcomes (surgical site infection, hematoma, flap necrosis, skin dimpling).

Statistical Analysis

Random-effects models were used to measure all pooled outcomes as described by Der Simonian and Laird[18] and the odds ratio (OR) was estimated with its variance and 95% confidence interval (CI). The random-effects analysis weighted the natural logarithm of each study's OR by the inverse of its variance plus an estimate of the between-study variance in the presence of between-study heterogeneity. As described previously,[19] heterogeneity between ORs for the same outcome between different studies was assessed using the I^2 inconsistency test and Chi-square-based Cochran's Q statistic test[20] in which a p-value <0.05 is taken to indicate the presence of significant heterogeneity. Analyses were conducted using Review Manager 5.3.

RESULTS

Eligible Studies

Twenty-one studies[21–41] containing data comparing quilting versus no quilting sutures in patients undergoing mastectomy with or without ALND were included (Table 1). The initial search found 358 studies. After excluding duplicates and unrelated studies based on abstract triage, 47 full texts were assessed for eligibility, of which 21 matched the inclusion criteria and were

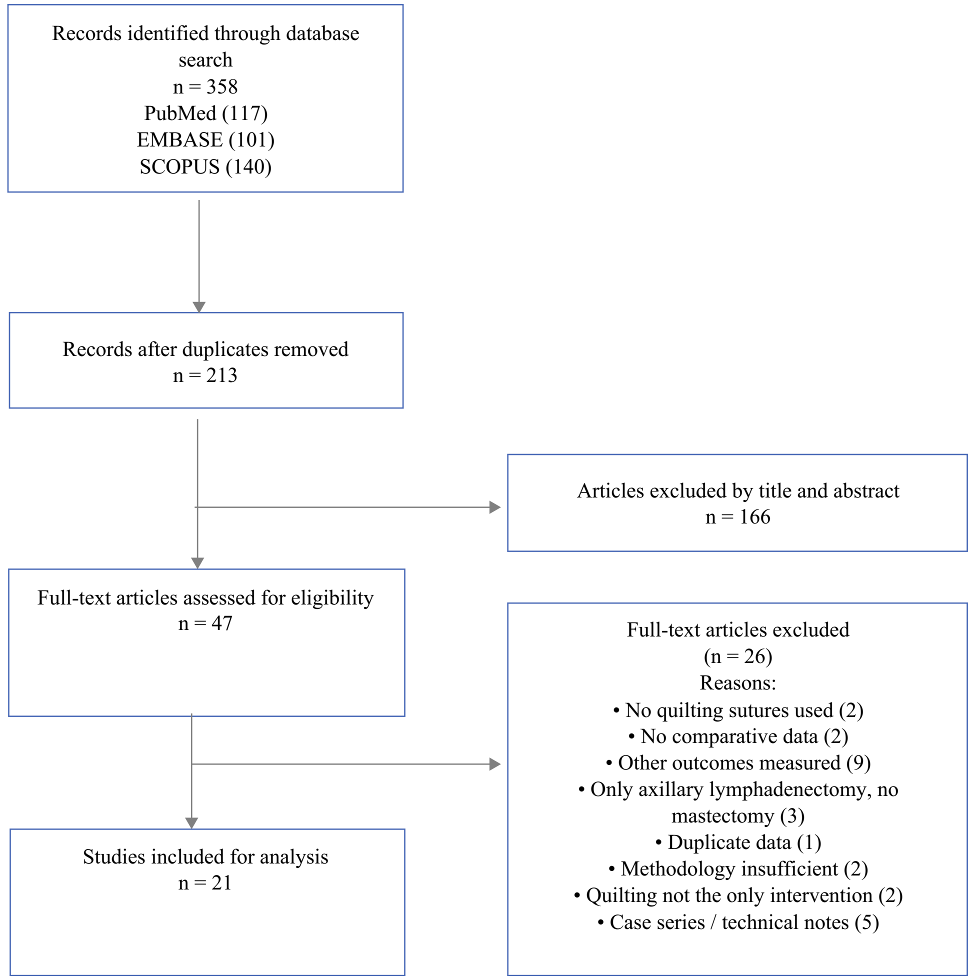


FIG. 1 PRISMA diagram. *PRISMA* Preferred Reporting Items for Systematic Reviews and Meta-Analyses

systematically reviewed. Year of publication of the included studies ranged from 2002 to 2021. Most studies were randomized control trials ($n = 10$),[23–25,27,31,34,36,38,39,41] followed by prospective cohort studies ($n = 7$)[21,22,28,29,32,37,40] and retrospective studies ($n = 4$).[26,30,33,35] The total number of included patients was 3473, split into two groups: study group (SG; $n = 1736$) and control group (CG; $n = 1737$). In the SG, the mastectomy flaps with ($n = 9$)[21,23,31,34–38,40] or without the axilla ($n = 10$)[22,24–28,30,32,33,41] were quilted using interrupted or continuous polyglactin sutures. In most studies, interrupted polyglactin 3/0 sutures were used between the skin flaps and the pectoralis major muscle. Mean age in the SG was 55.1 versus 54.9 in the CG. Mean BMI was 26.5 in both groups. By far, the most common procedure was modified mastectomy (SG, $n = 844$; CG, $n = 873$), followed by mastectomies with SLNB (M+SB) and simple mastectomies (M) (Table 1). Studies did not report if and what proportion of mastectomies were skin- or nipple-sparing.

Risk Factors for Seroma Formation

Body Mass Index Fourteen studies[21,23–27,31–36,39,40] describing 1838 patients included data on patients' BMI in QS versus standard closure after breast cancer surgery. Both groups were similar in this regard, having comparable BMI values with a mean difference of 0.02, however with considerable interstudy heterogeneity (mean difference 0.02, 95% CI −0.60 to 0.64, $p = 0.95$, Chi-square = 55.82, $I^2 = 77\%$) (Fig. 3a).

Neoadjuvant Therapy Nine studies[21,24,26,27,29,33,35–37] including data on 1155 patients described how many had neoadjuvant therapy in the two groups. No statistical difference and heterogeneity were seen between the SG and the CG (OR 0.89, 95% CI 0.67–1.19, $p = 0.43$, Chi-square = 6.51, $I^2 = 0\%$) (Fig. 3b).

Operative Time Seven studies[21,23,25,32–34,39] including data on 782 patients measured the operative time between the SG and the CG. QS were not associated with a significant increase in operative time compared with

TABLE 1 Study characteristics

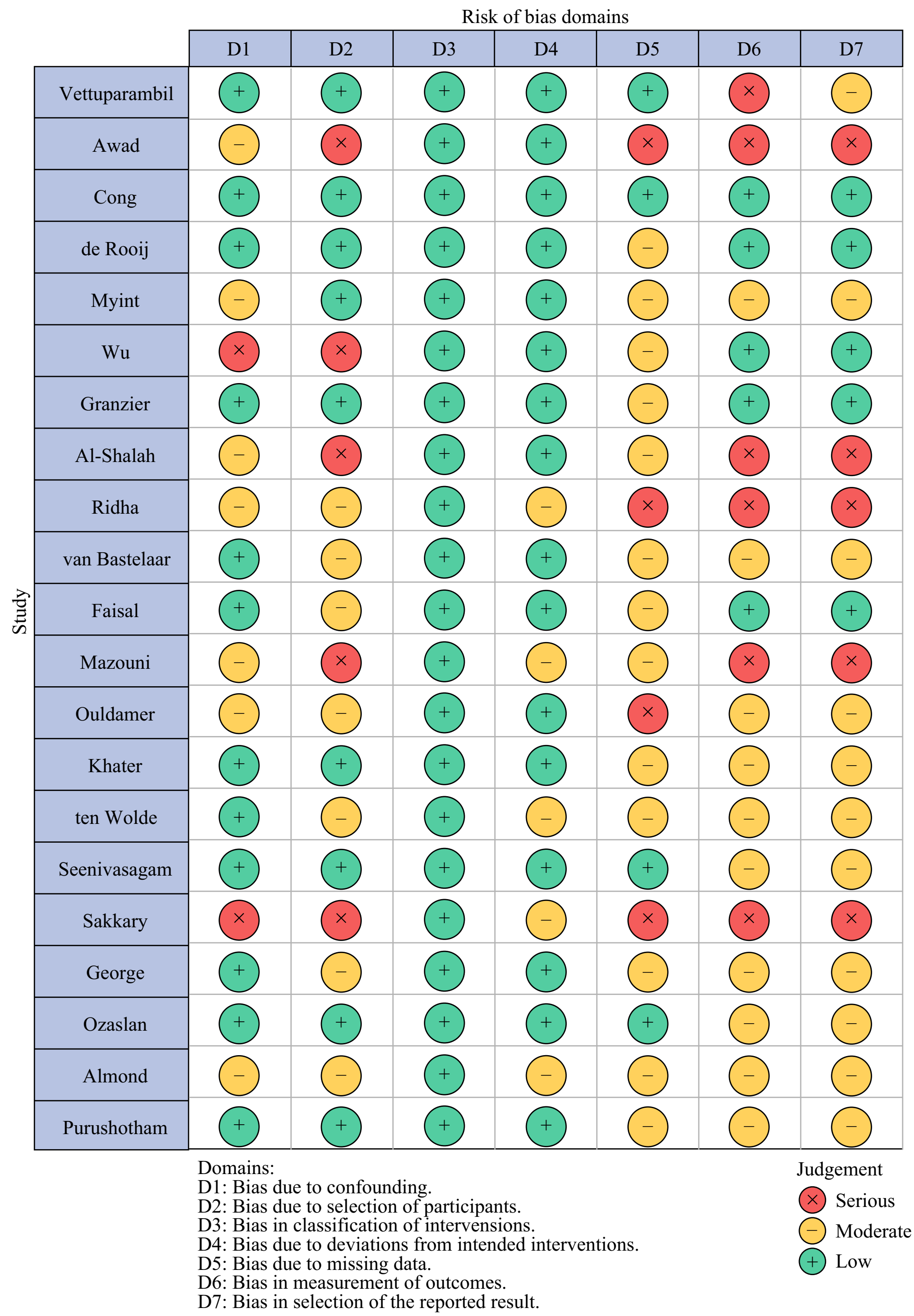
First author	Year	Study type	No. of patients			SG type of procedure		CG type of procedure		Quilting technique of flaps	Axillary quilting?	Mean age, years		Mean BMI		No. of drains used		Newcastle–Ottawa score
			Total	SG	CG							SG	CG	SG	CG	SG	CG	
Vettuparambil[21]	2021	Prospective	61	30	31	MRM	30	MRM	31	Interrupted 3/0 Polyglactin	Yes	50.2	47.8	23.9	24.5	2	2	7
Awad[22]	2020	Prospective	800	400	400	MRM	400	MRM	400	Interrupted 3/0 Polyglactin	No	NR	NR	NR	NR	2	2	5
Cong[23]	2020	RCT	160	80	80	MRM	23	MRM	27	Interrupted 4/0 Polyglactin	Yes	50.9	49.3	25.1	24.4	2	2	8
						M+SB	57	M+SB	53									
de Rooij[24]	2020	RCT	339	111	115	MRM	33	MRM	42	Interrupted 3/0 Polyglactin	No	65.4	64.1	28	27.4	1	1	8
						M+SB	64	M+SB	64									
						M	14	M	9									
Myint[25]	2020	RCT	140	70	70	MRM	70	MRM	70	Interrupted 3/0 Polyglactin	No	49.6	51.3	26.2	25.3	1	2	7
Wu[26]	2020	Retrospective	235	116	119	MRM	98	MRM	100	Interrupted	No	52.7	50.8	22.7	22.9	1	2	6
						M+SB	18	M+SB	19	Sutures								
Granzier[27]	2019	RCT	187	62	61	MRM	18	MRM	22	Interrupted 3/0 Polyglactin	No	65.6	63.2	27.3	27.1	1	1	8
						M	44	M	39									
Al-Shalah[28]	2018	Prospective	82	35	47	MRM	35	MRM	47	Interrupted 2/0 Polyglactin	No	NR	NR	NR	NR	1	2	5
Ridha[29]	2017	Prospective	78	39	39	MRM	39	MRM	39	Interrupted 3/0 Polyglactin	No	47.3	45.3	NR	NR	2	2	5
van Bastelaar[30]	2016	Retrospective	180	92	88	MRM	33	MRM	32	Interrupted 3/0 Polyglactin	No	67	71	NR	NR	2	2	7
						M+SB	53	M+SB	42									
						M	14	M	6									
Faisal[31]	2016	RCT	64	32	32	MRM	32	MRM	32	Running 2/0 Polyglactin	Yes	48.9	47.5	30.2	31.7	2	2	7
Mazouni[32]	2015	Prospective	82	41	41	MRM	33	MRM	31	Interrupted 2/0 Polyglactin	No	57	60	26.3	26.1	1	1	6
						M+SB	5	M+SB	5									
						M	3	M	5									
Ouldamer[33]	2015	Retrospective	119	59	60	MRM	34	MRM	31	Running 0/0 Polyglactin	No	56.8	61	25.2	25.6	1	2	6
						M+SB	9	M+SB	11									
						M	16	M	18									
Khater[34]	2015	RCT	120	60	60	MRM	60	MRM	60	Running 2/0 Polyglactin	Yes	46	44	30.5	30.9	1	1	7
ten Wolde[35]	2014	Retrospective	176	89	87	MRM	34	MRM	53	Running 0/0 Polyglactin	Yes	62	60	26.3	26.3	1	1	6
Seenivasagam[36]	2013	RCT	97	49	48	MRM	38	MRM	44		Yes	48	50	24.8	25.4	2	2	7

Table 1 (continued)

First author	Year	Study type	No. of patients			SG type of procedure		CG type of procedure		Quilting technique of flaps	Axillary quilting?	Mean age, years		Mean BMI		No. of drains used		Newcastle–Ottawa score
			Total	SG	CG							SG	CG	SG	CG	SG	CG	
						BCS+ALND	7	BCS+ALND	4	Interrupted 2/0 Polyglactin								
Sakkary[37]	2012	Prospective	40	20	20	MRM	20	MRM	20	Interrupted 3/0 Polyglactin	Yes	51	54	NR	NR	2	2	5
George[38]	2011	RCT	80	40	40	MRM	40	MRM	40	Interrupted Polyglactin	Yes	NR	NR	NR	NR	2	2	6
Ozaslan[39]	2010	RCT	100	50	50	MRM	50	MRM	50	Interrupted 3/0 PDS	NR	51.8	48.1	27.1	28.2	2	2	6
Almond[40]	2010	Prospective	135	76	59	MRM	62	MRM	43	Interrupted 2/0 Polyglactin	Yes	66	65	27.5	25.5	0	2	6
						M	49	M	37									
Purushotham[41]	2002	RCT	375	185	190	MRM	185	MRM	190	Interrupted 3/0 Polyglactin	No	57	57.5	NR	NR	0	2	7

RCT randomized control trial, *MRM* modified radical mastectomy, *M* mastectomy, *SB* sentinel lymph node biopsy, *BCS* breast-conserving surgery, *ALND* axillary lymph node dissection, *NR* not recorded, *SG* study group, *CG* control group, *BMI* body mass index

FIG. 2 ROBINS-I risk-of-bias assessment. Assessment of the risk of bias was performed by two authors (SM and CC). Each study was classified as low/moderate/serious risk for each of the seven domains. Disagreements were resolved via consensus.



CC, with a mean difference of 6.3 min in favor of the CG, however with considerable interstudy heterogeneity (mean difference 6.30, 95% CI −3.83 to 16.43, $p = 0.22$, Chi-square = 276.02, $I^2 = 98\%$) [Fig. 3c].

Lymph Node Yield Nine studies[21,23,25,32,33,36–39] including data on 879 patients described the number of excised lymph nodes showing the extent of dissection between the two groups. There was no significant difference between the SG and CG in lymph node yield, with a mean difference of 1.01 lymph nodes (mean difference 1.01, 95% CI 0.21–2.34, $p = 0.13$, Chi-square = 106.73, $I^2 = 93\%$) (Fig. 3d).

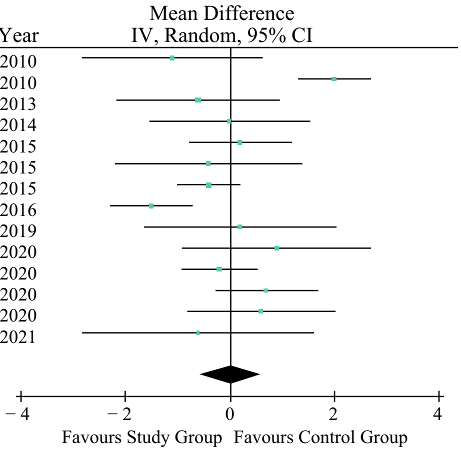
Outcomes of Quilting Sutures

Seroma Rate Twenty studies[21–28,30–41] including data on 3395 patients were analyzed based on seroma rates

(a)

Study or Subgroup	Study Group Mean	Study Group SD	Study Group Total	Control Group Mean	Control Group SD	Control Group Total	Weight	Mean Difference IV, Random, 95% CI	Year
Ozaslan 2010	27.1	4.1	50	28.2	4.7	50	5.8%	− 1.10 [− 2.83, 0.63]	2010
Almond 2010	27.5	2	76	25.5	2	59	9.3%	2.00 [1.32, 2.68]	2010
Seenivsagam 2013	24.8	3	49	25.4	4.6	48	6.3%	− 0.60 [− 2.15, 0.95]	2013
ten Wolde 2014	26.3	6	89	26.3	4.2	87	6.4%	0.00 [− 1.53, 1.53]	2014
Mazouni 2015	26.3	2.2	41	26.1	2.3	41	8.3%	0.20 [− 0.77, 1.17]	2015
Ouldamer 2015	25.2	4.9	59	25.6	5	60	5.6%	− 0.40 [− 2.18, 1.38]	2015
Khater 2015	30.5	1.8	60	30.9	1.5	60	9.6%	− 0.40 [− 0.99, 0.19]	2015
Faisal 2016	30.2	2	32	31.7	1	32	9.0%	− 1.50 [− 2.27, − 0.73]	2016
Granzier 2019	27.3	5.3	62	27.1	5.1	61	5.4%	0.20 [− 1.64, 2.04]	2019
Myint 2020	26.2	5.4	70	25.3	5.4	70	5.6%	0.90 [− 0.89, 2.69]	2020
Wu 2020	22.7	2.9	116	22.9	2.8	119	9.2%	− 0.20 [− 0.93, 0.53]	2020
Cong 2020	25.1	3	80	24.4	3.3	80	8.3%	0.70 [− 0.28, 1.68]	2020
de Rooij 2020	28	5.5	111	27.4	5.2	115	6.8%	0.60 [− 0.80, 2.00]	2020
Vettuparambil 2021	23.9	5	30	24.5	3.7	31	4.5%	− 0.60 [− 2.81, 1.61]	2021
Total (95% CI)			925			913	100.0%	0.02 [− 0.60, 0.64]	

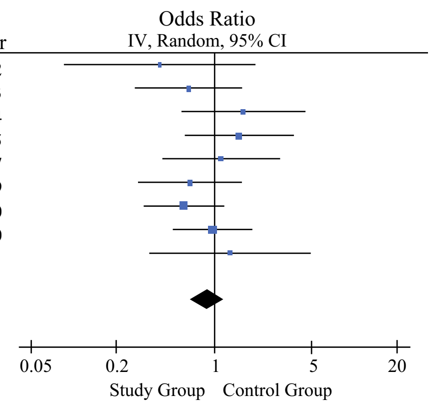
Heterogeneity: $Tau^2 = 0.94$, $Chi^2 = 55.82$, df = 13 ($P < 0.00001$): $I^2 = 77\%$
Test for overall effect: Z = 0.07 (P = 0.95)



(b)

Study or Subgroup	Study Group Events	Study Group Total	Control Group Events	Control Group Total	Weight	Odds Ratio IV, Random, 95% CI	Year
Sakkary 2012	3	20	6	20	3.5%	0.41 [0.09, 1.95]	2012
Seenivasagam 2013	13	49	17	48	11.1%	0.66 [0.28, 1.57]	2013
ten Wolde 2014	11	89	7	87	8.4%	1.61 [0.59, 4.37]	2014
Ouldamer 2015	15	59	11	60	10.9%	1.52 [0.63, 3.65]	2015
Ridha 2017	27	39	26	39	9.3%	1.13 [0.43, 2.91]	2017
Granzier 2019	12	62	16	61	11.6%	0.68 [0.29, 1.58]	2019
de Rooij 2020	19	111	29	115	19.9%	0.61 [0.32, 1.17]	2020
Wu 2020	23	116	24	119	20.5%	0.98 [0.52, 1.86]	2020
Vettuparambil 2021	6	30	5	31	4.9%	1.30 [0.35, 4.82]	2021
Total (95% CI)		575		580	100.0%	0.89 [0.67, 1.19]	
Total events	129		141				

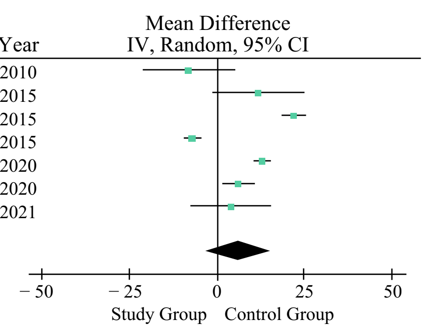
Heterogeneity: $Tau^2 = 0.00$, $Chi^2 = 6.51$, df = 8 ($P = 0.59$): $I^2 = 0\%$
Test for overall effect: Z = 0.78 (P = 0.43)



(c)

Study or Subgroup	Study Group Mean	Study Group SD	Study Group Total	Control Group Mean	Control Group SD	Control Group Total	Weight	Mean Difference IV, Random, 95% CI	Year
Ozaslan 2010	189.4	29.9	50	197.4	35.5	50	12.5%	− 8.00 [− 20.87, 4.87]	2010
Ouldamer 2015	113	34	59	101	38	60	12.5%	12.00 [− 0.95, 24.95]	2015
Khater 2015	127	10.5	60	105	7.5	60	15.4%	22.00 [18.74, 25.26]	2015
Mazouni 2015	78	5	41	85	5	41	15.6%	− 7.00 [− 9.16, − 4.84]	2015
Myint 2020	124.5	6.3	70	111.4	7	70	15.6%	13.10 [10.89, 15.31]	2020
Cong 2020	114.9	13.6	80	108.8	15.2	80	15.2%	6.10 [1.63, 10.57]	2020
Vettuparambil 2021	102	20	30	98	24	31	13.2%	4.00 [− 7.07, 15.07]	2021
Total (95% CI)			390			392	100.0%	6.30 [− 3.83, 16.43]	

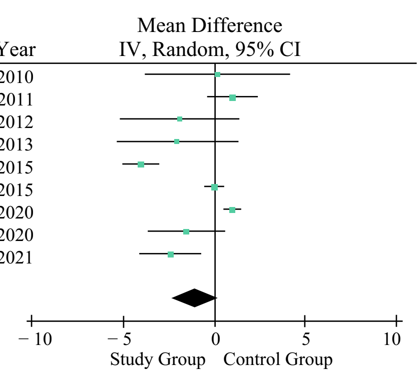
Heterogeneity: $Tau^2 = 170.30$, $Chi^2 = 276.02$, df = 6 ($P < 0.00001$): $I^2 = 98\%$
Test for overall effect: Z = 1.22 (P = 0.22)



(d)

Study or Subgroup	Study Group Mean	Study Group SD	Study Group Total	Control Group Mean	Control Group SD	Control Group Total	Weight	Mean Difference IV, Random, 95% CI	Year
Ozaslan 2010	25.4	9.8	50	25.2	10.3	50	6.4%	0.20 [− 3.74, 4.14]	2010
George 2011	16.8	3.2	40	15.8	3	40	12.7%	1.00 [− 0.36, 2.36]	2011
Sakkary 2012	18.9	5.2	20	20.8	5.3	20	7.8%	− 1.90 [− 5.15, 1.35]	2012
Seenivasagam 2013	14	6	49	16	10	48	7.7%	− 2.00 [− 5.29, 1.29]	2013
Mazouni 2015	10	2.1	41	14	2.3	41	13.7%	− 4.00 [− 4.95, − 3.05]	2015
Ouldamer 2015	8	1.3	59	8	1.5	60	14.4%	0.00 [− 0.50, 0.50]	2015
Myint 2020	9	1.2	70	8	1.2	70	14.5%	1.00 [0.60, 1.40]	2020
Cong 2020	6.1	6	80	7.6	7.3	80	10.8%	− 1.50 [− 3.57, 0.57]	2020
Vettuparambil 2021	16.9	2.8	30	19.3	3.7	31	12.0%	− 2.40 [− 4.04, − 0.76]	2021
Total (95% CI)			439			440	100.0%	− 1.01 [− 2.34, 0.31]	

Heterogeneity: $Tau^2 = 3.11$, $Chi^2 = 106.73$, df = 8 ($P < 0.00001$): $I^2 = 93\%$
Test for overall effect: Z = 1.50 (P = 0.13)



◀**FIG. 3** Meta analysis of risk factors for seroma formation and increased postoperative drainage: **a** BMI; **b** neoadjuvant therapy; **c** operative time; and **d** lymph node yield. Each study is shown by the point estimate of the OR/mean difference (square proportional to the weight of each study) and 95% CI for the OR (extending lines); the combined ORs/mean difference and 95% CIs by random effects calculations are shown by diamonds. **a** SG versus CG and BMI ($n = 1838$, $p = 0.95$; test for heterogeneity Cochran Q: 55.82, df: 13, $p < 0.00001$, I^2: 77%). **b** SG versus CG and neoadjuvant therapy ($n = 1155$, $p = 0.43$; test for heterogeneity Cochran Q: 6.51, df: 8, $p = 0.59$, I^2: 0%). (**c**) SG versus CG and operative time ($n = 782$, $p = 0.22$; test for heterogeneity Cochran Q: 276.02, df: 6, $p < 0.00001$, I^2: 98%). **d** SG versus CG and lymph node yield ($n = 879$, $p = 0.13$; test for heterogeneity Cochran Q: 106.73, df: 8, $p < 0.00001$, I^2: 93%). *BMI* body mass index, *OR* odds ratio, *CI* confidence interval, *SG* study group, *CG* control group, *df* degrees of freedom

between the SG and the CG. The addition of QS significantly reduced the risk of seroma formation in the SG (OR 0.32, 95% CI 0.21–0.49, $p < 0.00001$, Chi-square = 94.22, $I^2 = 80\%$) (Fig. 4a).

Total Volume of Drainage Fifteen studies[21–27,29,31,34–39] including data on 2500 patients measured the total volume of drainage between the SG and the CG. The total volume of drainage was significantly less in the QS group, with a mean difference of 474.9 mL. Interstudy heterogeneity in terms of volume of drainage was high (mean difference 474.99, 95% CI 337.58–612.40, $p < 0.00001$, Chi-square = 1909.81, $I^2 = 99\%$) (Fig. 4b).

Days to Drain Removal Nine studies[21–23,25,31,34,37–39] including data on 1565 patients analyzed the number of days until drains were removed in QS versus CC. All studies used an output-based approach in deciding when to remove the drains. In all studies, drains were removed when output was between 20 and 50 mL/24 h. Some studies kept the drains until the output was similar (20–50 mL) for 2 or 3 consecutive days.[22,23,25] Drains were removed earlier in the SG by a mean difference of 3.3 days (mean difference 3.32, 95% CI 1.29–5.34, $p < 0.00001$, Chi-square = 790.17, $I^2 = 99\%$) (Fig. 4c).

Length of Stay Six studies[25,26,32,33,40,41] including data on 1086 patients compared length of hospitalization between the two groups. Patients who had QS had a shorter length of stay compared with the CG, with a mean difference in hospitalization of 0.7 days (mean difference 0.71, 95% CI 0.19–1.22, $p = 0.007$, Chi-square = 68.06, $I^2 = 93\%$) [Fig. 4d].

Wound Complications

Surgical Site Infections Fourteen studies[21,23–27,30,31,35,37–41] including data on 2134 patients compared the rates of local wound infections between patients with QS and patients without. There was no statistical difference in terms of wound infections between the two groups (OR 0.70, 95% CI 0.48–1.02, $p < 0.07$, Chi-square = 17.11, $I^2 = 24\%$) (Fig. 5a).

Hematoma Formation Seven studies[21,23,25,26,30,32,34] including data on 978 patients compared the rates of hematoma formation between the two groups. QS were not associated with an increased risk of hematoma formation (OR 1.30, 95% CI 0.72–2.34, $p = 0.38$, Chi-square = 5.11, $I^2 = 0\%$) (Fig. 5b).

Flap Necrosis Seven studies[21,23,25,31,34,37,39] including data on 685 patients analyzed the incidence of mastectomy flap necrosis between patients with QS and patients without. There was no significant difference between the two groups (OR 0.58, 95% CI 0.27–1.23, $p = 0.15$ Chi-square 1.75, $I^2 = 0\%$) (Fig. 5c).

Skin Dimpling Four studies[23–25,27] including data on 649 patients analyzed whether patients with QS have higher rates of skin dimpling on the skin flaps. QS were not associated with an increased risk of skin dimpling (OR 1.13, 95% CI 0.71–1.82, $p = 0.61$, Chi-square = 1.12, $I^2 = 0\%$) [Fig. 5d].

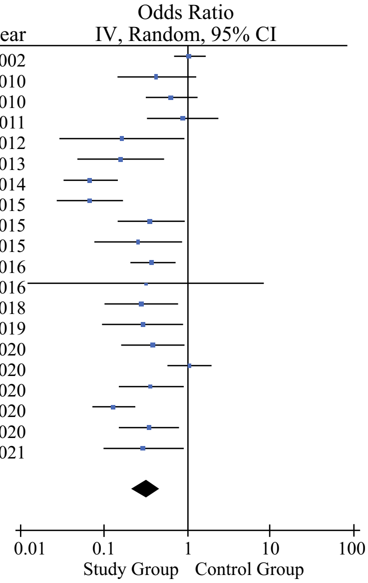
DISCUSSION

Our analysis showed that the addition of QS resulted in fewer seromas, less drainage, and shorter length of stay without increasing wound complications. In terms of risk factors for seroma formation, both groups were comparable. Fixation of the mastectomy flaps can be safely used to reduce postoperative drainage. While individual studies showed good outcomes even when drainage is omitted, it is too early to say whether QS are the missing piece towards drain-free mastectomies, as mentioned in De Rooij's recent systematic review.[42] This is the most updated meta-analysis on the role of QS after mastectomy and the only one to meta-analyse the two groups in terms of risk factors for seroma formation, outcomes, and associated wound complications. We chose to include all comparative studies, not only RCTs, as the data provided were easily matched with the data in the RCTs and the cohorts were comparable without overpowering the rest. In the last 5 years, 11

(a)

Study or Subgroup	Study Group Events	Study Group Total	Control Group Events	Control Group Total	Weight	Odds Ratio IV, Random, 95% CI	Year
Purushotham 2002	98	185	98	190	6.4%	1.06 [0.71, 1.59]	2002
Ozaslan 2010	6	50	12	50	4.7%	0.43 [0.15, 1.26]	2010
Almond 2010	37	76	35	59	5.8%	0.65 [0.33, 1.29]	2010
George 2011	11	40	12	40	5.0%	0.89 [0.34, 2.33]	2011
Sakkary 2012	2	20	8	20	3.2%	0.17 [0.03, 0.92]	2012
Seenivsagam 2013	4	49	17	48	4.4%	0.16 [0.05, 0.53]	2013
ten Wolde 2014	20	89	70	87	5.7%	0.07 [0.03, 0.15]	2014
Khater 2015	12	60	47	60	5.3%	0.07 [0.03, 0.17]	2015
Mazouni 2015	14	41	24	41	5.2%	0.37 [0.15, 0.90]	2015
Ouldamer 2015	4	59	13	60	4.4%	0.26 [0.08, 0.86]	2015
van Bastelaar 2016	33	92	52	88	6.0%	0.39 [0.21, 0.71]	2016
Faisal 2016	0	32	1	32	1.3%	0.32 [0.01, 8.23]	2016
Al-Shalah 2018	7	35	22	47	4.9%	0.28 [0.10, 0.78]	2018
Granzier 2019	5	62	14	61	4.7%	0.29 [0.10, 0.88]	2019
Myint 2020	10	70	21	70	5.4%	0.39 [0.17, 0.90]	2020
Wu 2020	32	116	31	119	6.1%	1.08 [0.61, 1.93]	2020
de Rooij 2020	8	111	20	115	5.3%	0.37 [0.16, 0.88]	2020
Awad 2020	14	400	87	400	6.0%	0.13 [0.07, 0.23]	2020
Cong 2020	10	80	23	80	5.4%	0.35 [0.16, 0.80]	2020
Vettuparambil 2021	8	30	17	31	4.7%	0.30 [0.10, 0.88]	2021
Total (95% CI)		1697		1698	100.0%	0.32 [0.21, 0.49]	
Total events	335		624				

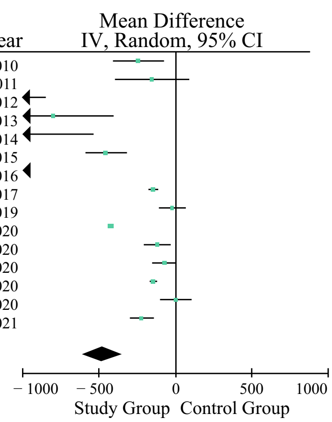
Heterogeneity: $Tau^2 = 0.67$, $Chi^2 = 94.22$, df = 19 ($P < 0.00001$): $I^2 = 80\%$
Test for overall effect: Z = 5.31 ($P < 0.00001$)



(b)

Study or Subgroup	Study Group Mean	Study Group SD	Study Group Total	Control Group Mean	Control Group SD	Control Group Total	Weight	Mean Difference IV, Random, 95% CI	Year
Ozaslan 2010	630.7	271.6	50	873.5	513.9	50	7.0%	− 242.80 [− 403.91, − 81.69]	2010
George 2011	448.8	445	40	597.8	623	40	6.3%	− 149.00 [− 386.26, 88.26]	2011
Sakkary 2012	524.8	651	20	2,017.8	1,300	20	2.9%	− 1493.00 [− 2130.18, − 855.82]	2012
Seenivsagam 2013	958	470	49	1,756	1,300	48	4.8%	− 798.00 [− 1188.60, − 407.40]	2013
ten Wolde 2014	611	754.4	89	1,660	2,322	87	3.7%	− 1049.00 [− 1561.48, − 536.52]	2014
Khater 2015	710	290	60	1,160	420	60	7.3%	− 450.00 [− 579.14, − 320.86]	2015
Faisal 2016	1,476	518	32	4,525	97.6	32	6.8%	− 3049.00 [− 3231.63, − 2866.37]	2016
Ridha 2017	212.8	55	39	357.6	70.5	39	7.7%	− 144.80 [− 172.86, − 116.74]	2017
Granzier 2019	261.8	217.3	62	279.7	234.4	61	7.6%	− 17.90 [− 97.81, 62.01]	2019
Awad 2020	246	78.9	400	664.7	69.4	400	7.8%	− 418.70 [− 429.00, − 408.40]	2020
Cong 2020	460.9	242.9	80	574.8	285.2	80	7.6%	− 113.90 [− 195.99, − 31.81]	2020
de Rooij 2020	246	285.1	111	316.2	302.9	115	7.6%	− 70.20 [− 146.87, 6.47]	2020
Wu 2020	374.9	57.1	116	520.5	84.3	119	7.8%	− 145.60 [− 163.97, − 127.23]	2020
Myint 2020	385.4	315.7	70	381.8	254.3	70	7.5%	3.60 [− 91.37, 98.57]	2020
Vettuparambil 2021	449.6	76	30	666.6	183.5	31	7.6%	− 217.00 [− 287.09, − 146.91]	2021
Total (95% CI)			1248			1252	100.0%	− 474.99 [− 612.40, − 337.58]	

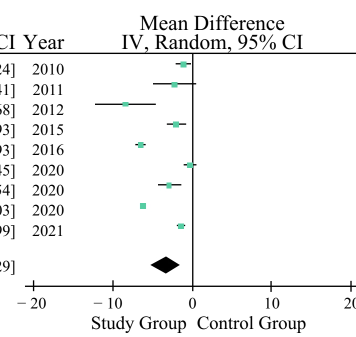
Heterogeneity: $Tau^2 = 63220.86$, $Chi^2 = 1909.81$, df = 14 ($P < 0.00001$): $I^2 = 99\%$
Test for overall effect: Z = 6.78 ($P < 0.00001$)



(c)

Study or Subgroup	Study Group Mean	Study Group SD	Study Group Total	Control Group Mean	Control Group SD	Control Group Total	Weight	Mean Difference IV, Random, 95% CI	Year
Ozaslan 2010	5.6	1.7	50	6.7	2.6	50	11.6%	− 1.10 [− 1.96, − 0.24]	2010
George 2011	7	5.6	40	9.2	6.3	40	9.9%	− 2.20 [− 4.81, 0.41]	2011
Sakkary 2012	5	6	20	13.4	6	20	8.5%	− 8.40 [− 12.12, − 4.68]	2012
Khater 2015	9	3	60	11	3	60	11.5%	− 2.00 [− 3.07, − 0.93]	2015
Faisal 2016	11.3	1.3	32	17.8	1	32	11.8%	− 6.50 [− 7.07, − 5.93]	2016
Myint 2020	6	2.1	70	6.3	2.4	70	11.7%	− 0.30 [− 1.05, 0.45]	2020
Cong 2020	10.9	3.2	80	13.8	5.3	80	11.3%	− 2.90 [− 4.26, − 1.54]	2020
Awad 2020	4.7	0.8	400	10.9	1.5	400	11.9%	− 6.20 [− 6.37, − 6.03]	2020
Vettuparambil 2021	4.6	0.6	30	6	1	31	11.8%	− 1.40 [− 1.81, − 0.99]	2021
Total (95% CI)			782			783	100.0%	− 3.32 [− 5.34, − 1.29]	

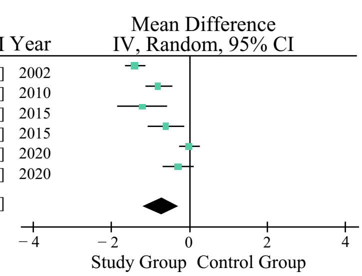
Heterogeneity: $Tau^2 = 8.97$, $Chi^2 = 790.17$, df = 8 ($P < 0.00001$): $I^2 = 99\%$
Test for overall effect: Z = 3.21 (P = 0.001)



(d)

Study or Subgroup	Study Group Mean	Study Group SD	Study Group Total	Control Group Mean	Control Group SD	Control Group Total	Weight	Mean Difference IV, Random, 95% CI	Year
Purushotham 2002	4.1	1.3	185	5.5	1.1	190	17.7%	− 1.40 [− 1.64, − 1.16]	2002
Almond 2010	1.8	0.9	76	2.6	1	59	17.2%	− 0.80 [− 1.13, − 0.47]	2010
Ouldamer 2015	4.2	2.1	59	5.4	1.2	60	14.6%	− 1.20 [− 1.82, − 0.58]	2015
Mazouni 2015	4.9	1	41	5.5	1.1	41	16.1%	− 0.60 [− 1.06, − 0.14]	2015
Wu 2020	7.8	1	116	7.8	1	119	17.6%	0.00 [− 0.26, 0.26]	2020
Myint 2020	7.4	1	70	7.7	1.2	70	16.9%	− 0.30 [− 0.67, 0.07]	2020
Total (95% CI)			547			539	100.0%	− 0.71 [− 1.22, − 0.19]	

Heterogeneity: $Tau^2 = 0.37$, $Chi^2 = 68.06$, df = 5 ($P < 0.00001$): $I^2 = 93\%$
Test for overall effect: Z = 2.70 (P = 0.007)



◀**FIG. 4** Meta analysis of outcomes after quilting sutures in terms of **a** seroma rate; **b** total volume of drainage; **c** days to drain removal; and **d** length of stay. Each study is shown by the point estimate of the OR/mean difference (square proportional to the weight of each study) and 95% CI for the OR (extending lines); the combined ORs/mean difference and 95% CIs by random effects calculations are shown by diamonds. **a** SG versus CG and seroma rate ($n = 3395$, $p < 0.00001$; test for heterogeneity Cochran Q: 94.22, df: 19, $p < 0.00001$, I^2: 80%). **b** SG versus CG and total volume of drainage ($n = 2500$, $p < 0.00001$; test for heterogeneity Cochran Q: 1909.81, df: 14, $p < 0.00001$, I^2: 99%). **c** SG versus CG and days to drain removal ($n = 1565$, $p = 0.001$; test for heterogeneity Cochran Q: 790.17, df: 8, $p < 0.00001$, I^2: 99%). **d** SG versus CG and length of stay ($n = 1086$, $p = 0.007$; test for heterogeneity Cochran Q: 68.06, df: 5, $p < 0.00001$, I^2: 93%). *OR* odds ratio, *CI* confidence interval, *SG* study group, *CG* control group, *df* degrees of freedom

studies have been published on this subject,[21–31] of which five were RCTs.[23–25,27,31] This is a strong suggestion that QS should be adopted more in standard surgical practice.

Increased drainage and seroma formation are regarded as the most common complications after breast surgery, thus increasing costs etc.[1–3] Closed suction drainage is the single widespread technique for reducing seroma formation and while it clearly has a crucial role, research efforts have been made to reduce drainage even more. Quilting the mastectomy flaps and the axilla is a simple yet promising technique based on the building evidence validating its beneficial role. In 2016, Chen et al.[43] performed a meta-analysis that included RCTs and which compared quilting versus non-quilting after axillary dissection, excluding case-control studies, and concluded by supporting the use of QS. In 2018, van Bastelaar et al.[2] performed a systematic review comparing tissue glue and QS in reducing seroma formation. While both showed better outcomes than CC, QS were not superior to tissue glue. This was contradicted by the RCT published by de Rooij et al. in 2021[42] that showed better outcomes in the sutures group compared with tissue glue.

Whenever used, QS showed reduced postoperative drainage, however few surgeons still use them and this is likely explained by the initial longer operative time. Furthermore, there is a fear that anchoring the flaps to the muscle will lead to increased pain on shoulder movement and may lead to dimpling and bumping of the skin surface. In our study, we could not compare the postoperative pain associated with QS as insufficient studies provided data on the visual analog scale of pain. However, the operative time and dimpling were similar in both groups. Once mastered, QS should not affect the aesthetics of wound closure as they are widely used in anchoring various flaps in breast reconstructive procedures without reported issues.[44–46]

High BMI, increased operative time, neoadjuvant therapy, use of cautery, extent of lymph node dissection, type and number of drains used, tumor size, and presence of positive axillary lymph nodes have all been studied and have arguably been proven as risk factors for increased postoperative drainage and seroma formation.[9–13] In our analysis, we compared the two groups in terms of BMI, operative time, neoadjuvant therapy, and lymph node yield. Number of lymph nodes was used as an indirect marker of extent of lymph node dissection, which in turn increases the risk of prolonged drainage. These four were constant variables analyzed in the included manuscripts. No significant difference was found between the SG and the CG, reducing the risk of selection bias.

There are a couple of important differences in how authors reported each variable that needs to be considered, although the overall results are not affected. While quilting was performed with the same goal of decreasing the dead space, there was interstudy variability between quilting techniques. In most cases, interrupted polyglactin 3/0 was used on the upper and lower skin flaps. Some used a single or double layer of continuous polyglactin sutures in both flaps.[23,31,33–35] Furthermore, some authors, e.g. Cong et al.,[23] quilted the axilla also.

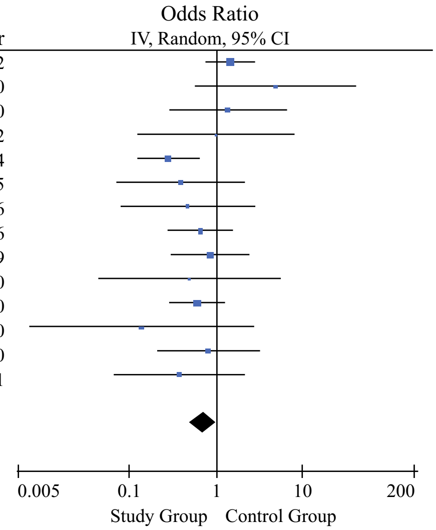
Not all studies defined seroma in the same way. In most scenarios, seromas were defined according to the Common Terminology Criteria for Adverse Events (CTCAE) Classification: grade 0, no seroma; grade 1, asymptomatic—clinically identified, but no intervention needed; grade 2, symptomatic, medical intervention required; grade 3, severe symptoms, radiological or surgical intervention needed. Other studies defined seroma only when clear fluid was aspirated from a palpable collection,[27,28,32,35,41] while others defined it as any palpable fluid collection after drain removal.[22,36,39] There were differences in how the drains were placed in both the SG and CG. Fifteen studies used the same number of drains in both groups (one or two drains),[21–24,27,29–32,34–39] while six studies[25,26,28,33,40,41] used fewer drains in the SG, thus proving QS can be used to replace at least the prepectoral drain. Seroma rate and volume and duration of drainage were better in the SG, both from a statistical and practical point of view. In terms of bedside management, a volume difference of 475 mL is important because it subsequently led to removing the drains sooner, by a mean of 3.3 days. Three days is a significant interval that should have a beneficial impact on the postoperative recovery of patients. In our analysis, quicker drain removal was not followed by a clinically relevant shorter hospital stay (mean difference 0.7 days) although it was statistically significant.

Using multiple QS between the dermis and the pectoralis muscle will naturally lead one to believe this will increase the risk of bleeding from the muscular bed and

(a)

Study or Subgroup	Study Group Events	Study Group Total	Control Group Events	Control Group Total	Weight	Odds Ratio IV, Random, 95% CI	Year
Purushotham 2002	26	185	19	190	17.0%	1.47 [0.78, 2.76]	2002
Almond 2010	6	76	1	59	2.8%	4.97 [0.58, 42.48]	2010
Ozaslan 2010	4	50	3	50	5.0%	1.36 [0.29, 6.43]	2010
Sakkary 2012	2	20	2	20	3.0%	1.00 [0.13, 7.89]	2012
ten Wolde 2014	10	89	27	87	13.2%	0.28 [0.13, 0.63]	2014
Ouldamer 2015	2	59	5	60	4.3%	0.39 [0.07, 2.07]	2015
Faisal 2016	2	32	4	32	3.9%	0.47 [0.08, 2.75]	2016
van Bastelaar 2016	11	92	15	88	12.4%	0.66 [0.29, 1.53]	2016
Granzier 2019	8	62	9	61	9.5%	0.86 [0.31, 2.39]	2019
Cong 2020	1	80	2	80	2.2%	0.49 [0.04, 5.56]	2020
de Rooij 2020	14	111	22	115	14.7%	0.61 [0.29, 1.26]	2020
Myint 2020	0	70	3	70	1.5%	0.14 [0.01, 2.70]	2020
Wu 2020	4	116	5	119	6.3%	0.81 [0.21, 3.11]	2020
Vettuparambil 2021	2	30	5	31	4.1%	0.37 [0.07, 2.08]	2021
Total (95% CI)		1072		1062	100.0%	0.70 [0.48, 1.02]	
Total events	92		122				

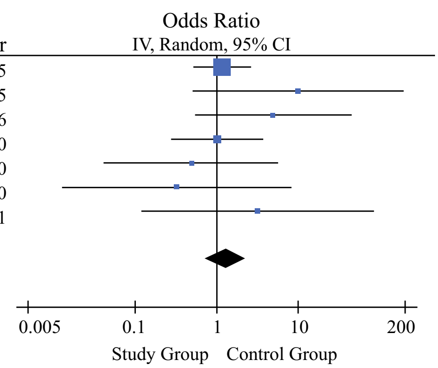
Heterogeneity: $Tau^2 = 0.11$, $Chi^2 = 17.11$, df = 13 (P = 0.19): $I^2 = 24\%$
Test for overall effect: Z = 1.83 (P = 0.07)



(b)

Study or Subgroup	Study Group Events	Study Group Total	Control Group Events	Control Group Total	Weight	Odds Ratio IV, Random, 95% CI	Year
Khater 2015	18	60	16	60	54.6%	1.18 [0.53, 2.61]	2015
Mazouni 2015	4	41	0	41	4.0%	9.96 [0.52, 191.23]	2015
van Bastelaar 2016	5	92	1	88	7.4%	5.00 [0.57, 43.68]	2016
Wu 2020	5	116	5	119	21.5%	1.03 [0.29, 3.65]	2020
Cong 2020	1	80	2	80	5.9%	0.49 [0.04, 5.56]	2020
Myint 2020	0	70	1	70	3.3%	0.33 [0.01, 8.21]	2020
Vettuparambil 2021	1	30	0	31	3.3%	3.20 [0.13, 81.78]	2021
Total (95% CI)		489		489	100.0%	1.30 [0.72, 2.34]	
Total events	34		25				

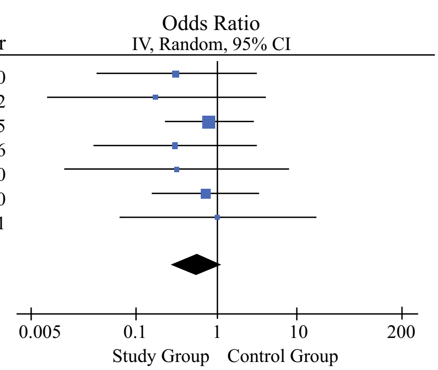
Heterogeneity: $Tau^2 = 0.00$, $Chi^2 = 5.11$, df = 6 (P = 0.53): $I^2 = 0\%$
Test for overall effect: Z = 0.88 (P = 0.38)



(c)

Study or Subgroup	Study Group Events	Study Group Total	Control Group Events	Control Group Total	Weight	Odds Ratio IV, Random, 95% CI	Year
Ozaslan 2010	1	50	3	50	10.7%	0.32 [0.03, 3.18]	2010
Sakkary 2012	0	20	2	20	5.9%	0.18 [0.01, 4.01]	2012
Khater 2015	5	60	6	60	36.4%	0.82 [0.24, 2.84]	2015
Faisal 2016	1	32	3	32	10.5%	0.31 [0.03, 3.17]	2016
Myint 2020	0	70	1	70	5.4%	0.33 [0.01, 8.21]	2020
Cong 2020	3	80	4	80	24.1%	0.74 [0.16, 3.42]	2020
Vettuparambil 2021	1	30	1	31	7.1%	1.03 [0.06, 17.33]	2021
Total (95% CI)		342		343	100.0%	0.58 [0.27, 1.23]	
Total events	11		20				

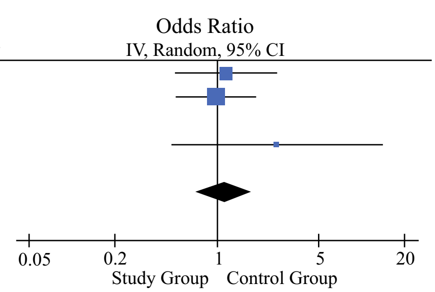
Heterogeneity: $Tau^2 = 0.00$, $Chi^2 = 1.75$, df = 6 (P = 0.94): $I^2 = 0\%$
Test for overall effect: Z = 1.43 (P = 0.15)



(d)

Study or Subgroup	Study Group Events	Study Group Total	Control Group Events	Control Group Total	Weight	Odds Ratio IV, Random, 95% CI	Year
Granzier 2019	17	62	15	61	34.4%	1.16 [0.52, 2.60]	2019
de Rooij 2020	25	111	26	115	57.6%	1.00 [0.53, 1.86]	2020
Myint 2020	0	70	0	70		Not estimable	2020
Cong 2020	5	80	2	80	8.0%	2.60 [0.49, 13.81]	2020
Total (95% CI)		323		326	100.0%	1.13 [0.71, 1.82]	
Total events	47		43				

Heterogeneity: $Tau^2 = 0.00$, $Chi^2 = 1.12$, df = 2 (P = 0.57): $I^2 = 0\%$
Test for overall effect: Z = 0.52 (P = 0.61)



◀**FIG. 5** Meta-analysis of complications after quilting sutures in terms of **a** surgical site infection; **b** hematoma; **c** flap necrosis; and **d** skin dimpling. Each study is shown by the point estimate of the OR/mean difference (square proportional to the weight of each study) and 95% CI for the OR (extending lines); the combined ORs/mean difference and 95% CIs by random effects calculations are shown by diamonds. **a** SG versus CG and surgical site infections ($n = 2134$, $p = 0.07$; test for heterogeneity Cochran Q: 17.11, df: 13, $p = 0.19$, I^2: 24%). **b** SG versus CG and hematoma formation ($n = 978$, $p = 0.38$; test for heterogeneity Cochran Q: 5.11, df: 6, $p = 0.53$, I^2: 0%). (**c**) SG versus CG and flap necrosis ($n = 685$, $p = 0.15$; test for heterogeneity Cochran Q: 1.75, df: 6, $p = 0.94$, I^2: 0%). **d** SG versus CG and skin dimpling ($n = 649$, $p = 0.61$; test for heterogeneity Cochran Q: 1.12, df: 2, $p = 0.57$, I^2 0%). *OR* odds ratio, *CI* confidence interval, *SG* study group, *CG* control group, *df* degrees of freedom

asymmetric dimpling of the skin. For this reason, we sought to analyze wound complications. Most studies had enough data, apart from skin dimpling, which was compared in only four manuscripts.[23–25,27] This was the smallest dataset in our study and it may need further research. In three studies,[23,24,27] skin dimpling alongside wound cosmesis was assessed by an independent, blinded surgeon during outpatient follow-up. The investigator assessed for skin dimpling at every follow-up visit. In one study,[23] skin dimpling was only quantified at 3 months. Even though not as important as in reconstructions, the wound cosmesis of patients who undergo non-reconstructive mastectomy is still an important factor to consider. In such scenarios, dimpling caused either by misplaced sutures or skin excess leads to wound deformity and impacts the patient-reported cosmesis. In our analysis, dimpling was not increased by QS when sutures were placed by an experienced surgeon. de Rooij et al.[24] also analyzed shoulder discomfort, as QS would, in theory, increase pain on movement due to the sutures anchored to the pectoralis muscle. They did not report any correlation between QS and shoulder discomfort.

While all studies described in detail the quilting technique in non-skin-sparing mastectomies, none showed how QS should be placed in skin- or nipple-sparing mastectomies without immediate breast reconstruction. In such cases, it is more difficult to attach the flaps to the muscular bed, and, even when done, the redundant skin will still lead to skin dimpling and wound asymmetry. In modified radical mastectomies, QS have a clear beneficial role, but further research should clarify how QS should be used in oncoplastic mastectomies, which are now standard procedures.

CONCLUSION

The building body of evidence strongly supports the use of QS after non-skin-sparing mastectomies to reduce seroma rate, volume and duration of drainage, and length of stay. This meta-analysis reiterated the beneficial role of QS in improving postoperative outcomes without increasing wound complication rates.

FUNDING No funding or financial assistance was received by the authors.

DISCLOSURES Stefan Morarasu, Cillian Clancy, Nicolae Ghetu, Ana Maria Musina, Natalia Velenciuc, Stefan Iacob, Tudor Frunza, Cristian Ene Roata, Sorinel Lunca, and Gabriel-Mihail Dimofte have no conflicts of interest to disclose.

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