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The impact of surgical drains on postoperative complications following DIEP flap breast reconstruction: a multicentre cohort study

Zoë MA Kuijlaars

zoe.kuijlaars@mumc.nl

Maastricht University Medical Centre +

Daan GE Janssen

Maastricht University Medical Centre +

Limburg DIEP Group

Maastricht University Medical Centre +

Jop Beugels

Maastricht University Medical Centre +

René RWJ Hulst

Maastricht University Medical Centre +

Andrzej A Piatkowski

Maastricht University Medical Centre +

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Abstract

BACKGROUND – The deep inferior epigastric perforator (DIEP) flap is widely used for autologous breast reconstruction. Postoperative fluid-related complications, including seroma, remain a concern. Surgical drains are commonly placed to prevent fluid accumulation. This study evaluates the association between drain use and postoperative complications at both donor and recipient sites.

METHODS – A retrospective multicentre cohort study was performed including all patients undergoing DIEP flap breast reconstruction between 2010 and 2024. Primary outcomes were seroma and hematoma formation. Mixed-effects models were used to account for clustering in bilateral procedures.

RESULTS – A total of 2,286 flaps in 1,739 patients were analysed. Of these, 1,656 (95.2%) were included in the drain group and 83 (4.8%) in the no-drain group, reflecting a marked cohort imbalance. Recipient-site hematoma rates were higher in the drain group, while seroma rates were comparable. Drain use was not independently associated with recipient-site complications. At both the recipient and donor sites, drain placement was not associated with reduced odds of seroma or hematoma in univariable or multivariable analysis.

CONCLUSIONS - Drain placement was not associated with reduced rates of seroma or hematoma at either donor or recipient site. These findings question the routine use of drains in DIEP flap breast reconstruction.

Level of Evidence: III (Retrospective comparative study)

Introduction

The deep inferior epigastric perforator (DIEP) flap is widely used for autologous breast reconstruction because it provides a natural breast contour while preserving abdominal muscle integrity and minimizing donor-site morbidity.[1–4] Despite its advantages, postoperative fluid-related complications such as hematoma and seroma formation, remain a concern at both the donor and recipient sites.

After flap harvest, the donor site is closed using an abdominoplasty technique that leaves a potential dead space in which seroma, defined as a post-operative fluid accumulation, may develop. The exact underlying mechanism of seroma remains incompletely understood. The presence of proteinases and cytokines in seroma fluid suggests an inflammatory exudative process rather than passive serosanguineous leakage,[5,6] while friction and shear forces between tissue planes may further amplify this inflammatory response.[7] At the recipient site, breast and axillary surgery disrupt vascular and lymphatic structures, and DIEP flap reconstruction causes comparable disruption at the donor site. This disruption reduces interstitial fluid clearance and increases the risks of postoperative fluid collections.[8]

Postoperative fluid-related complication rates after DIEP flap breast reconstruction vary. A ten-year review showed 4.6% hematoma and 1.8% seroma rates.[9] Recent multicentre data indicate recipient-site

hematoma rates of 5%.[10] Donor-site seromas (3.4–5.8%) occurred more frequently than recipient-site seromas (1.2–1.4%), whereas donor-site hematomas remained rare.[10]

Surgical drains are routinely placed by approximately 90% of surgeons to mitigate fluid accumulation in DIEP flap reconstruction,[3,11,12] with bilateral cases reaching up to six drains.[13] Although effective against seroma, itself an infectious nidus,[14,15] drains increase infection risk, prolong hospitalization, require daily care, limit mobility, and raise healthcare costs, while negatively impacting patient satisfaction.[3,4,13,16–19]

Despite their widespread use, postoperative drain management lacks consensus.[2,4,18,20–22] While various drain types are utilized, including passive, suction, sump, and negative pressure drains,[23,24] removal criteria vary substantially (production lower than5 till 80mL per day).[3,18,21,22] Several studies demonstrate that early removal, based on postoperative time rather than output, does not increase complication rates,[3,25] questioning whether postoperative drains are necessary at all.

To bypass drain-related disadvantages, alternative techniques such as tissue sealants, and (barbed) quilting sutures are employed.[21,26,27] First described by Pollock and Pollock, PTS reduces dead space by evenly distributing tension and minimizing shearing forces.[28] Studies report comparable seroma rates between PTS and drain-based approaches.[13,19,29–33] Furthermore, drain-free DIEP flap reconstructions are associated with shorter operative times, reduced length of hospital admission, less postoperative pain, improved mobility, and potentially reduced infection risk.[18,19,34,35]

The aim of this study was to evaluate the association between drain placement and postoperative complications which drains aim to prevent at both the donor and recipient sites following DIEP flap breast reconstruction, and to examine the relationship between drain use and clinical outcomes.

Methods

Study design and patients

A retrospective cohort study was conducted using a prospectively maintained database from three collaborating institutions (Maastricht University Medical Centre+, VieCuri Medical Centre and Zuyderland Medical Centre). All patients who underwent DIEP flap breast reconstruction between January 2010 and December 2024 were included. The study was performed in accordance with the Declaration of Helsinki. This study was reported in accordance with the STROBE guidelines. A completed STROBE checklist is provided as supplementary material.

The reconstructions were performed by a group of fourteen plastic surgeons across the participating hospitals, with most procedures and more complex cases carried out at the university hospital.

Drain use and postoperative management

Suction drains were placed at the recipient site, donor site, or both, according to surgeon preference. In addition to drains, other techniques such as quilting sutures were used at the preference of the surgeon, in the majority of cases in combination with drain placement. Postoperative drain management consisted of monitoring drain output every 24 hours. Criteria for drain removal were an output of < 30ml/24h, at least 24 hours postoperatively, and after adequate patient mobilization. Showering with drains was permitted from the third postoperative day onward, with the drain exit site covered using transparent film dressing. Patients were discharged with drains still in place if drain production exceeded 30ml/24h with scheduled appointments for removal.

Outcome measures

Patient characteristics (including age, referral source etc.), risk factors (including smoker, BMI, etc.), (neo)adjuvant therapies, pathology, operative details (including timing, type, operation length, drain placement, etc.), complications and follow-up were retrospectively extracted from medical records.

Postoperative complications were categorized as recipient-site or donor-site complications. This study specifically evaluated postoperative complications that the use of drains aims to prevent, namely seroma and hematoma formation. Seroma was diagnosed based on clinical assessment and/or confirmed by imaging, most commonly ultrasound. Hematoma was diagnosed based on clinical assessment and, when necessary, confirmed by imaging, most commonly ultrasound.

Data analysis

Analyses were performed in R (version 4.5.2) using the *lme4, lmerTest* and *mice* packages. Analyses were conducted either per patient (n = 1739) or per DIEP flap (n = 2286), depending on the data. Mean and standard deviation (SD) or median and interquartile range (IQR) were used for continuous variables, while count (n) and percentages were used for categorical variables. Patient-level analysis consisted of independent samples t-test or Mann-Whitney U test for continuous outcomes, and chi-square or Fisher's exact test for categorical outcomes. Flap-level analysis accounted for clustering in patients with bilateral reconstruction, therefore patients were included as a random effect in mixed-model analysis on flap level. Linear mixed models (LMM) analysis was used for continuous outcomes, and generalized linear mixed models (GLMM) analysis for categorical outcomes. Missing data in the cohort description were not imputed and are indicated below the respective tables. Missing data for the analysis of associations between recipient or donor site complications and risk factors were imputed using Predictive Mean Matching (PMM). Statistical significance was set at $p < 0.05$. Data analysis adhered to CLUDA guidelines for reporting bilateral procedures, with consultation from a biostatistician.[36]

Results

The total database included 2,286 DIEP flaps across 1,739 patients. Among the fourteen plastic surgeons, twelve routinely placed recipient-site drains, whereas at the donor site, only two maintained

drain placement; the others discontinued use between 2016 and 2023. Abdominal drains were not placed without concurrent recipient site breast drains.

Patient characteristics

Of the 1,739 patients, 1,656 (95.2%) were included in the drain group and 83 (4.8%) in the no-drain group, reflecting a marked cohort imbalance. Baseline characteristics were largely similar between cohorts, with treatment setting as the only notable difference, as patients in the non-drain group were more frequently treated at the university hospital. Median hospital stay was slightly longer in the drain group. A comprehensive overview of these baseline characteristics is provided in Table 1.

[Insert Table 1 here]

Recipient-site complications in relation to drain use

At the recipient site, hematoma occurred slightly more frequently in flaps with drains compared to those without (4.5% vs. 3.4%), while seroma rates were comparable between groups (1.1% vs. 2.5%; p = 0.838) (Table 2). In multivariable analysis, recipient-site drain placement was not independently associated with either hematoma or seroma formation (Table 3).

[Insert Table 2 here]

Donor-site complications in relation to drain use

Donor-site hematoma and seroma rates were comparable between patients with and without drains (hematoma: 1.5% vs. 1.8%; seroma: 3.3% vs. 2.1%) (Table 2). Neither univariable nor multivariable analyses identified any factor, including drain placement, as independently associated with donor-site hematoma or seroma (Table 3).

[Insert Table 3 here]

Discussion

In this large, multicentre cohort spanning over a decade, neither recipient- nor donor-site drain placement was associated with a reduction in hematoma or seroma formation following DIEP flap breast reconstruction. However, these findings should be interpreted in light of the retrospective study design, the marked imbalance between the drain and drainless cohorts, and potential residual confounding.

Limited literature is available on the effect of drains at the recipient site, as most studies have primarily focused on the abdominal donor site. In the present multicentre cohort, recipient-site drain placement was not associated with reduced odds of hematoma or seroma formation at its corresponding site in either univariable or multivariable analysis. These findings suggest that routine drain placement at the

breast recipient site may not provide additional benefit in preventing postoperative fluid-related complications following DIEP flap breast reconstruction. Although these findings question the routine use of recipient-site drains, they should not be interpreted as evidence of equivalence or superiority of a drainless approach.

Our findings differ partially from those reported by Kim et al., who observed a significantly higher incidence of breast seroma in patients undergoing total drainless reconstruction, however, their cohort was much smaller than ours (n = 294). Importantly, their study systematically evaluated fluid collections using routine postoperative ultrasound examinations, which may have increased the detection of clinically minor or asymptomatic seromas compared with relying primarily on clinical assessment. [37]

Notably, Kim et al. emphasized the importance of meticulous dead-space management in drainless breast reconstruction. In their total drainless cohort, quilting sutures were selectively applied to the lateral mastectomy flap and chest wall to reduce residual dead space. This supports the concept that adequate obliteration of dead space, rather than drain placement itself, may be the more critical determinant in preventing clinically significant seroma formation. Similar principles have been described in other areas of reconstructive and oncologic surgery, where quilting or progressive tension sutures reduce shear forces, eliminate potential fluid cavities, and diminish reliance on postoperative drainage systems.[38,39]

At the donor site, our findings corroborate prior studies reporting no significant benefit of drains in preventing hematoma or seroma. Similar findings were reported by Evgeniou et al., who found no significant differences in donor-site complications between patients with and without drains.[40] Other systematic reviews further supported these results and reported reduced postoperative pain and shorter hospital stay in patients without drains.[34,41] In contrast, Kim et al. observed higher donor-site seroma rates in patients without drains, although other abdominal complications were comparable between groups. Notably, their drainless protocol incorporated quilting sutures and fibrin sealants for dead-space obliteration, underscoring that adequate dead-space management, including quilting sutures, may be more important than drain placement itself in minimizing postoperative seroma formation. Nevertheless, because the present study was observational and drain placement was not randomized, causality cannot be inferred.

Importantly, multiple studies suggest that dead space reduction techniques, rather than drain placement itself, may be the critical factor in preventing donor site seroma formation. Chan et al. demonstrated that progressive tension sutures (PTS) without drains resulted in no seroma formation and significantly fewer abdominal-specific complications compared with conventional closure with drains, alongside shorter hospital stay.[42] Similarly, Brennan et al. reported low donor-site morbidity and acceptable seroma rates in a cohort undergoing DIEP donor site closure without drains or adjunctive dead space reduction techniques, suggesting that routine drain placement may be unnecessary.[4] In the present study, dead space reduction techniques such as quilting sutures were used at the discretion of the operating surgeon and were, in some cases, combined with drain placement or used as a standalone strategy.

However, the extent, consistency, and specific technique of dead space reduction were not systematically recorded in the database, precluding a detailed analysis of their independent effect on donor-site outcomes. Despite this limitation, the observed lack of seroma reduction supports the concept that surgical technique and dead space management may be more influential determinants of donor-site outcomes than the presence of drains alone.

Thereby our multicentre cohort included a broad BMI range representative of contemporary Western breast reconstruction practice. Importantly, multivariable analyses correcting for BMI and other potential confounders continued to demonstrate no protective association between drain placement and seroma or hematoma formation, despite the fact that higher BMI is generally associated with increased postoperative complication rates in DIEP breast reconstruction.[43,44] These findings suggest that routine drain use may also be unnecessary in patients with higher BMI. These findings suggest that no protective association between drain placement and postoperative complications was observed across a broad BMI range. However, these observations require confirmation in adequately powered prospective studies before recommendations can be extended to higher-risk patient groups.

Although drain placement was not directly associated with hematoma or seroma formation, the median hospital stay was slightly longer in the drain group (6 vs. 5 days, $p < 0.001$). However, given the retrospective nature of this study, it cannot be determined whether the prolonged admission was directly attributable to drain placement or to other perioperative factors that may have prompted drain insertion and additional postoperative monitoring. It is possible that patients perceived to be at higher risk for postoperative complications were more likely to receive drains and consequently required longer postoperative observation.

Limitations

The retrospective design introduces the risk of information bias due to reliance on medical records. Potential sources include inter-observer interpretation of documentation, incomplete or inaccurate records and manual data entry errors during database construction. Selection bias was limited by inclusion of all patients who underwent DIEP flap breast reconstruction during the study period. A major limitation of this study is the difference in group sizes, which may explain observed differences in hematoma and seroma rates. Due to the relatively low incidence rates of individual complications, generalized linear mixed model and logistic regression analyses were only feasible for total recipient- or donor-site drain-related complications, rather than specific complication types, such as seroma. Finally, drain placement was frequently combined with quilting sutures, which may confound the isolated effect of drains.

Conclusions

In this large multicentre cohort, neither recipient- nor donor-site drain placement following DIEP flap breast reconstruction was associated with reduced odds of seroma or hematoma formation. These

findings support reconsidering the routine use of surgical drains, while emphasizing the importance of meticulous surgical technique and adequate dead-space management across a broad range of patient characteristics, including patients with higher BMI. Although these findings contribute to the growing body of evidence questioning the routine use of surgical drains, they should be interpreted with caution given the retrospective design, the marked imbalance between study groups and the potential for residual confounding. Prospective comparative studies are required before changes to routine clinical practice can be recommended.

Declarations

Author Contribution

All authors contributed equally to the concept, design, drafting and revision of this manuscript. All authors approved the final version of the article and agree to be accountable for all aspects of the work

Acknowledgement

Group authorship statementThe Limburg DIEP Group consists of plastic surgeons from three centres in Limburg, the Netherlands, who performed DIEP flap breast reconstructions from January 2010 to December 2024. See Appendix A. Group membersRené RWJ van der Hulst, MD PhD1, Stefania MH Tuinder, MD, PhD1, Shan S Qiu, MD, PhD1, Andrzej A Piatkowski, MD, PhD1,3,5, Bianca Rijken, MD, PhD1, John H Sawor, MD6, Darren I Booi, MD, PhD1, Marleen AJ Meesters-Caberg, MD7, Tom van Mulken, MD PhD1,7, An EK Deliaert, MD, PhD6

References

1. Nahabedian MY (2023) The deep inferior epigastric perforator flap: where we started and where we are now. ;(2227-684X (Print))
2. Lim B, Seth I, Joseph K et al (2024) Optimal Use of Drain Tubes for DIEP Flap Breast Reconstruction: Comprehensive Review. J Clin Med 13(21):6586. 10.3390/jcm13216586
3. Miranda BH, Amin K, Chana JS (2014) The drain game: Abdominal drains for deep inferior epigastric perforator breast reconstruction. *Journal of Plastic, Reconstructive & Aesthetic Surgery*. /07/01/ 2014;67(7):946–950. https://doi.org/10.1016/j.bjps.2014.03.020
4. Brennan C, Katsura C, Whitehouse H, Allouni A, Akali A (2023) Drain-free donor site in Deep Inferior Epigastric Perforator free flap: A single-surgeon experience. *Journal of Plastic, Reconstructive & Aesthetic Surgery*. /10/01/ 2023;85:59–64. https://doi.org/10.1016/j.bjps.2023.01.011
5. Baker EA, Leaper DJ (2000) Proteinases, their inhibitors, and cytokine profiles in acute wound fluid. Article. Wound Repair Regeneration 8(5):392–398. 10.1046/j.1524-475X.2000.00392.x

6. Watt-Boolsen S, Nielsen VB, Jensen J, Bak S (1989) Postmastectomy seroma. A study of the nature and origin of seroma after mastectomy. Article. Dan Med Bull 36(5):487–489
7. Pollock T, Pollock H (2004) Progressive tension sutures in abdominoplasty. *Clinics in Plastic Surgery*. /10/01/ 2004;31(4):583–589. https://doi.org/10.1016/j.cps.2004.03.015
8. McCarthy C, Lennox P, Germann E, Clugston P (2005) Use of Abdominal Quilting Sutures for Seroma Prevention in TRAM Flap Reconstruction:: A Prospective, Controlled Trial. Ann Plast Surg. ;54(4)
9. Gill PS, Hunt JP, Guerra AB et al (2004) A 10-year retrospective review of 758 DIEP flaps for breast reconstruction. Review. Plast Reconstr Surg 113(4):1153–1160. 10.1097/01.PRS.0000110328.47206.50
10. Beugels J, Hoekstra LT, Tuinder SMH, Heuts EM, van der Hulst RRWJ, Piatkowski AA (2016) Complications in unilateral versus bilateral deep inferior epigastric artery perforator flap breast reconstructions: A multicentre study. J Plast Reconstr Aesthetic Surg 69(9):1291–1298 2016/09/01/. https://doi.org/10.1016/j.bjps.2016.04.010
11. Ogawa H, Tahara S Postoperative Showering for Patients With Closed Suction Drainage: A Retrospective Cohort Study of Deep Inferior Epigastric Perforator Flap Breast Reconstructions. Cureus. 2022-03-01 2022;14doi:10.7759/cureus.23665
12. Lim B, Seth I, Joseph K et al Optimal Use of Drain Tubes for DIEP Flap Breast Reconstruction: Comprehensive Review. J Clin Med. 2024-11-01 2024;13doi:10.3390/jcm13216586
13. Nagarkar P, Lakhiani C, Cheng A, Lee M, Teotia S, Saint-Cyr M (2016) No-drain DIEP Flap Donor-site Closure Using Barbed Progressive Tension Sutures. Plast Reconstr Surg – Global Open. ;4(4)
14. Ota D, Fukuuchi A, Iwahira Y et al Identification of complications in mastectomy with immediate reconstruction using tissue expanders and permanent implants for breast cancer patients. Breast Cancer. 2016/05/01 2016;23(3):400–406. 10.1007/s12282-014-0577-4
15. Phillips BT, Wang ED, Mirrer J et al (2011) Current practice among plastic surgeons of antibiotic prophylaxis and closed-suction drains in breast reconstruction: Experience, evidence, and implications for postoperative care. :460–465
16. Durai R, Mownah A, Philip CHN (2009) Use of Drains in Surgery: A Review. *Journal of Perioperative Practice*. /06/01 2009;19(6):180–186. 10.1177/175045890901900603
17. Ollech CJ, Block LM, Afifi AM, Poore SO (2017) Effect of Drain Placement on Infection, Seroma, and Return to Operating Room in Expander-Based Breast Reconstruction. Article. Ann Plast Surg 79(6):536–540. 10.1097/SAP.0000000000001174
18. Scomacao I, Cummins A, Roan E, Duraes EFR, Djohan R (2020) The use of surgical site drains in breast reconstruction: A systematic review. J Plast Reconstr Aesthetic Surg 73(4):651–662 2020/04/01/. https://doi.org/10.1016/j.bjps.2019.11.019
19. Thacoor A, Kanapathy M, Torres-Grau J, Chana J (2018) Deep inferior epigastric perforator (DIEP) flap: Impact of drain free donor abdominal site on long term patient outcomes and duration of inpatient stay. J Plast Reconstr Aesthetic Surg 2018/08/01(8):1103–1107. https://doi.org/10.1016/j.bjps.2018.04.019

20. Ogawa H, Tahara S Postoperative Showering for Patients With Closed Suction Drainage: A Retrospective Cohort Study of Deep Inferior Epigastric Perforator Flap Breast Reconstructions. Cureus. 2022/3/30 2022;14(3):e23665. 10.7759/cureus.23665
21. Liang DG, Dusseldorp JR, van Schalkwyk C et al (2016) Running barbed suture quilting reduces abdominal drainage in perforator-based breast reconstruction. J Plast Reconstr Aesthetic Surg 69(1):42–47 2016/01/01. https://doi.org/10.1016/j.bjps.2015.09.009
22. Paolini G, Sorotos M, Firmani G, Santanelli di Pompeo F A Simple Method for Quantitative Assessment of Suction Drains. Aesthetic Plast Surg. 2020/06/01 2020;44(3):1099–1101. 10.1007/s00266-020-01685-3
23. Robinson JO (1986) Surgical drainage: An historical perspective. Br J Surg 73(6):422–426. 10.1002/bjs.1800730603
24. Meyerson JM (2016) A brief history of two common surgical drains. Review. Ann Plast Surg 77(1):4–5. 10.1097/SAP.0000000000000734
25. Grigg K, Clancy R, Lewis C, Jackson P (2021) 931 Deep Inferior Epigastric Perforator (DIEP) Flap: Impact of Early Drain Removal on Seroma Formation Rate and Duration of Inpatient Stay. Br J Surg 108(Supplement6):znab259706. 10.1093/bjs/znab259.706
26. Fertsch S, Michalak M, Andree C et al (2022) Randomized Single-Center Study of Effectiveness and Safety of a Resorbable Lysine-Based Urethane Adhesive for a Drain-Free Closure of the Abdominal Donor Site in a DIEP Flap Breast Reconstruction Procedure. *Journal of Investigative Surgery*. /06/01 2022;35(6):1404–1414. 10.1080/08941939.2022.2046215
27. Pollock H, Pollock T (2000) Progressive tension sutures: a technique to reduce local complications in abdominoplasty. ;(0032-1052 (Print))
28. Jabbour S, Awaida C, Mhawej R, Bassilios Habre S, Nasr M (2017) Does the Addition of Progressive Tension Sutures to Drains Reduce Seroma Incidence After Abdominoplasty? A Systematic Review and Meta-Analysis. ;(1527-330X (Electronic))
29. Pollock TA, Pollock H No-drain abdominoplasty with progressive tension sutures. 2010;(1558 – 0504 (Electronic))
30. Antonetti JW, Antonetti AR (2010) Reducing seroma in outpatient abdominoplasty: analysis of 516 consecutive cases. ;(1527-330X (Electronic))
31. Andrades P, Prado A, Fau - Danilla S, Danilla S, Fau - Guerra C et al (2007) Progressive tension sutures in the prevention of postabdominoplasty seroma: a prospective, randomized, double-blind clinical trial. ;(1529–4242 (Electronic))
32. Chan SLS, Rutherford C, Kong TY (2020) No-drain Technique in Abdominal Closure for Breast Reconstruction: Lower Complication Rate, Shorter Hospitalization Stay. Plast Reconstr Surg – Global Open. ;8(2)
33. Zolper EG, Bekeny JC, Fan KL, Del Corral GA (2020) Incidence of Complications in Delayed Abdominal-Based Flap Breast Reconstruction Using a Drainless Recipient Site: A Case Series. ; (1536–3708 (Electronic))

34. Wong PY, Chansiriwongs A (2024) 1269 Comparing Patient Outcomes for Drain vs Drain-Less Technique in Abdominal Donor-Site Closure Following Deep Inferior Epigastric Perforator Flap Breast Reconstruction: A Systematic Review. BJS 111(Supplement6):znae163532. 10.1093/bjs/znae163.532
35. Khan AA, Wood B, Abdul Z, Rahman S, Allouni A (2021) The Drain Dilemma: A Systematic Review and Meta-Analysis of Drain-Free Abdominal Closure With Progressive Tension Sutures Against Drain-Assisted Closure for Abdominal Flaps in Breast Reconstruction. ;(2168–8184 (Print))
36. Hemmingsen MN, Nygaard CMT, Kaufmann A et al (2022) How to Report Data on Bilateral Procedures and Other Issues with Clustered Data: The CLUDA Reporting Guidelines. ;(1529–4242 (Electronic))
37. Kim J, Lee K-T, Mun G-H (2024) Shifting toward total drainless approach in DIEP flap-based breast reconstruction: Evaluation of safety. J Plast Reconstr Aesthetic Surg 95:152–160 2024/08/01/. https://doi.org/10.1016/j.bjps.2024.05.027
38. Brown T, Murphy K, Murphy T (2023) The Effect of Drains and Compressive Garments Versus Progressive Tensioning Sutures on Seroma Formation in Abdominoplasty. Aesthetic Plast Surg 10(5):1905–1910. 10.1007/s00266-022-03244-4. /01 2023
39. Rao G, Daneshi K, Ceccaroni A et al (2025) A Systematic Review and Meta-Analysis Evaluating the Surgical Outcomes of Progressive Tension Suturing Compared to Drains in Abdominoplasty Surgery. Aesthetic Surg J 45(1):71–83. 10.1093/asj/sjae171
40. Evgeniou E, Liew J, Lee G et al (2023) Are Surgical Drains Needed in DIEP Flap Surgery? The Drain-Free DIEP Flap Concept. Plast Reconstr Surg. ;152(4)
41. Li M, Wang K (2021) Efficacy of Progressive Tension Sutures without Drains in Reducing Seroma Rates of Abdominoplasty: A Systematic Review and Meta-Analysis. *Aesthetic Plastic Surgery*. /04/01 2021;45(2):581–588. 10.1007/s00266-020-01913-w
42. Chan SLS, Rutherford C, Kong TY (2020) No-drain Technique in Abdominal Closure for Breast Reconstruction: Lower Complication Rate, Shorter Hospitalization Stay. Plast Reconstr Surg Glob Open Feb 8(2):e2637. 10.1097/gox.0000000000002637
43. Fisher M, Ohmes L, Yang J et al Abdominal donor-site complications following autologous breast reconstruction: A multi-institutional multisurgeon study. *Journal of plastic, reconstructive & aesthetic surgery: JPRAS*. 2024-02-01 2024;90:88–94. 10.1016/j.bjps.2024.01.033
44. White-Dzuro CG, Haddock NT (2025) Comparing autologous breast reconstruction in high vs. low body mass index patients. Gland Surg Dec 31(12):2433–2439. 10.21037/gs-2025-337

Tables

Table 1. Patient characteristics (n=1739).

	No drains n (%)	≥ 1 Drain* n (%)	*p* value
No. DIEP flaps	119	2167	
No. Patients	83	1656	
Age at operation in years; mean ± SD	50.4 ± 10.8	51.5 ± 9.2	0.380
BMI (kg/m^2); mean ± SD	27.0 ± 3.5	26.8 ± 3.9	0.546
Operating hospital			**<0.001**
University	77 (92.8)	1065 (64.3)	
Community	6 (7.2)	591 (35.7)	
Smoker	10 (12.0)	185 (11.2)	0.956
Previous abdominal surgeries	36 (43.4)	638 (39.1)	0.507
(Neo) Adjuvant therapy [a]			
Radiation therapy	22 (26.5)	544 (33.2)	0.249
Chemotherapy	42 (51.2)	898 (55.2)	0.554
Endocrine therapy	28 (34.1)	687 (42.8)	0.153
Immunotherapy	6 (7.3)	158 (9.9)	0.569
Type of reconstruction [a]			0.430
Unilateral	46 (38.7)	1194 (55.1)	
Bilateral	73 (61.3)	972 (44.9)	
Timing of reconstruction [a]			0.155
Immediate	58 (48.7)	929 (42.9)	
Delayed	61 (51.3)	1235 (57.1)	
Reason for mastectomy [a]			0.948
Oncologic	105 (88.2)	1929 (89.6)	
Risk reducing	14 (11.8)	223 (10.4)	
Hospital stay in days; median (IQR) [a]	5 (4 – 5)	6 (5 – 7)	**<0.001**
Follow-up in months; median (IQR) [a]	12.0 (8.0 – 20.5)	12.0 (6.0 – 20.0)	0.683

* Drains used at recipient and/or donor site.

[a] Flaps as unit of analysis n=2286;

Table 2. Drain-related postoperative complications at the recipient and donor site.

Recipient site (n=2286)	**No recipient-site drains n (%)**	**≥ 1 Recipient-site drains n (%)**	***p* value**
No. flaps	119	2167	
Hematoma	**4 (3.4)**	**98 (4.5)**	**<0.001**
Seroma	3 (2.5)	24 (1.1)	0.838
Donor site (n=1739 patients)	**No donor-site drains n (%)**	**≥ 1 Donor -site drains n (%)**	***p* value**
No. patients	563	1176	
Hematoma	10 (1.8)	16 (1.5)	0.605
Seroma	12 (2.1)	36 (3.3)	0.148

Corrected for timing of reconstruction, donor site analysis was also corrected for BMI.

Table 3. Analysis of risk factors associated with recipient and donor site hematoma and seroma.

Risk factor	Univariable analysis		Multivariable analysis	
	OR (95%CI)	*p* value	OR (95%CI)	*p* value
Recipient site				
Timing (delayed vs. immediate)	0.544 (0.168 – 1.760)	0.309	0.542 (0.167 – 1.755)	0.307
BMI (kg/m2)	1.012 (0.865 – 1.183)	0.885	1.013 (0.867 – 1.184)	0.868
≥1 Recipient-site drains	1.214 (0.061 – 24.139)	0.899	1.266 (0.063 – 25.387)	0.877
Donor site				
BMI (kg/m2)	1.046 (0.987 – 1.107)	0.120	1.042 (0.983 – 1.103)	0.157
Previous abdominal surgery	1.487 (0.930 – 2.373)	0.096	1.451 (0.906 – 2.320)	0.120
≥1 Donor-site drains	1.138 (0.693 – 1.928)	0.619	1.151 (0.701 – 1.954)	0.588