



# Comparing Seroma Formation at the Deep Inferior Epigastric Perforator, Transverse Musculocutaneous Gracilis, and Superior Gluteal Artery Perforator Flap Donor Sites after Microsurgical Breast Reconstruction

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## Abstract

**Background** Seroma formation is the most common donor site complication following autologous breast reconstruction, along with hematoma. Seroma may lead to patient discomfort and may prolong hospital stay or delay adjuvant treatment. The aim of this study was to compare seroma rates between the deep inferior epigastric perforator (DIEP), transverse musculocutaneous gracilis (TMG), and superior gluteal artery perforator (SGAP) donor sites.

**Methods** The authors conducted a retrospective single-center cohort study consisting of chart review of all patients who underwent microsurgical breast reconstruction from April 2018 to June 2020. The primary outcome studied was frequency of seroma formation at the different donor sites. The secondary outcome evaluated potential prognostic properties associated with seroma formation. Third, the number of donor site seroma evacuations was compared between the three donor sites.

**Results** Overall, 242 breast reconstructions were performed in 189 patients. Demographic data were found statistically comparable between the three flap cohorts, except for body mass index (BMI). Frequency of seroma formation was highest at the SGAP donor site (75.0%), followed by the TMG (65.0%), and DIEP (28.6%) donor sites. No association was found between seroma formation and BMI, age at surgery, smoking status, diabetes mellitus, neoadjuvant chemotherapy, or DIEP laterality. The mean number of seroma evacuations was significantly higher in the SGAP and the TMG group compared with the DIEP group.

## Keywords

- ▶ seroma
- ▶ mammoplasty
- ▶ surgical flaps
- ▶ microsurgery

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**Conclusion** This study provides a single center's experience regarding seroma formation at the donor site after microsurgical breast reconstruction. The observed rate of donor site seroma formation was comparably high, especially in the TMG and SGAP group, necessitating an adaption of the surgical protocol.

## Introduction

Seroma formation is the most common donor site complication following autologous breast reconstruction, along with hematoma.<sup>1</sup> Although seromas usually resolve spontaneously, they can lead to patient discomfort and may have deleterious consequences, including wound complications such as infection or wound breakdown. They may also lead to prolonged recovery time which may delay adjuvant treatment for breast cancer.<sup>2-4</sup> Seromas are most commonly treated with sterile fine-needle evacuation which may result in multiple outpatient visits or prolonged hospital stays and increased postoperative costs.<sup>3,5</sup> The senior author's practice has focused on breast reconstruction after mastectomy. The aim of this study was to compare seroma rates between the deep inferior epigastric perforator (DIEP), transverse musculocutaneous gracilis (TMG) and superior gluteal artery perforator (SGAP) flap donor sites after autologous breast reconstruction. The authors also aimed at identifying associated factors for seroma formation. Furthermore, the number of seroma evacuations was compared between the three donor sites.

## Methods

### Study Design/Sample

A retrospective cohort study consisting of a chart review was performed. All patients who underwent microsurgical breast reconstruction at the senior author's center from April 2018 to June 2020 were included. The flap types used included DIEP, TMG, and SGAP flaps. Microsurgical breast reconstruction was performed either in the oncologic setting due to breast cancer, in the prophylactic setting due to a gene mutation or after implant removal due to capsular contracture following a previous mastectomy.

### Outcomes

The primary outcome measure was the frequency of donor site seroma in each flap group. The secondary outcome measure was to evaluate if any of the following factors had prognostic properties for or an association with seroma formation: body mass index (BMI), age at surgery, smoking status, diabetes mellitus, and neoadjuvant chemotherapy (last chemotherapy no more than 8 weeks prior to reconstruction), and if the DIEP flap was taken from the abdomen unilaterally or bilaterally (laterality of the DIEP flap). As a tertiary question, the authors compared the number of donor site seroma evacuations between the three different flap groups.

### Statistical Analysis

Deidentified data were analyzed using the software STATA 16 (StataCorp LLC, 2019, TX). For statistical analysis pur-

poses, transverse rectus abdominis myocutaneous (TRAM) and superficial inferior epigastric artery (SIEA) flaps were included in the DIEP group, and one profunda artery perforator (PAP) reconstruction was added to the TMG group. TMG and transverse upper gracilis (TUG) flaps were treated as one group.

Categorical variables were described as numbers and percentages. As the continuous variables were not normally distributed (Shapiro-Wilk test), they were presented as median and interquartile range (IQR). A Chi-square test was used to assess if donor site seroma formation depended on the flap type. A Fischer's exact test was performed to determine possible associations between seroma formation and the independent predictors mentioned above. The receiver operating characteristic (ROC) analysis was performed to assess BMI and age as potential predictors of seroma formation. The optimal cut-off point was assessed by the Youden index. To compare the number of seroma evacuations between the DIEP, TMG, and SGAP flap groups, a Kruskal-Wallis test with a post hoc Dunn's test was used. All tests were considered statistically significant at  $p < 0.05$ .

### Surgical Protocol

Preoperatively, all cases were discussed at the breast cancer diagnostic conference. Computed tomography (CT) angiography of the abdominal wall was performed if a DIEP flap was planned. The patient's general practitioner provided a list of comorbidities and performed a physical examination, electrocardiogram, as well as basic laboratory tests before surgery. All procedures were performed by one of three board-certified reconstructive microsurgeons following the standard operating procedure (SOP). All skin incisions were done with a 10-blade scalpel and further dissection was performed with monopolar, as well as bipolar, cautery. Veins were anastomosed using a venous coupling device (Synovis, Inc., Birmingham AL). Arteries were hand-sewn using DaFilon 9-0. The donor site was closed in standard fashion over closed Redon suction drains, and the flaps were inset to restore the breast footprint over Redon drains as well. A pressure garment was applied to the donor site and removed 6 weeks postoperatively. All patients received intravenous (IV) tranexamic acid (Cyklokapron, MEDA Pharma GmbH, Wangen-Brüttisellen, Switzerland) of 1 g during induction of anesthesia. If increased bleeding was noted during surgery, 1 g of IV tranexamic acid was repeated 8 hours after starting surgery. IV cefazolin of 2 g (Cefazolin Labatec, Labatec Pharma SA, Meyrin, Switzerland) was started as antibiotic prophylaxis after induction and continued until postoperative day (POD) 3. Only crystalloids were infused. Fluid management was goal directed, considering diuresis and

blood pressure. Anesthesiologists were advised to avoid hypervolemia to prevent edema and damage to glycocalyx. Postoperative monitoring was performed as described previously; every 15 minutes during the first 3 hours; every hour thereafter until the evening of POD 1; every 3 hours thereafter until the evening of POD 2; and once per shift thereafter, in the case of an uncomplicated previous course. Parameters included were color and temperature of the skin monitor island, as well as Doppler signal.<sup>6</sup>

### Postoperative Management

Redon suction drains were removed when the delivery rate went below 30 mL/24 h. After hospital discharge, clinical follow-ups were performed by plastic surgeons and breast surgeons at regular intervals. If seroma formation was identified clinically as a palpable fluid collection, the diagnosis was confirmed using ultrasonographic imaging. If the size of the seroma permitted aspiration, this was performed under sterile conditions guided by ultrasonography. The aspiration was conducted using an 18-gauge needle attached to a Redon suction bottle, enabling a vacuum effect.

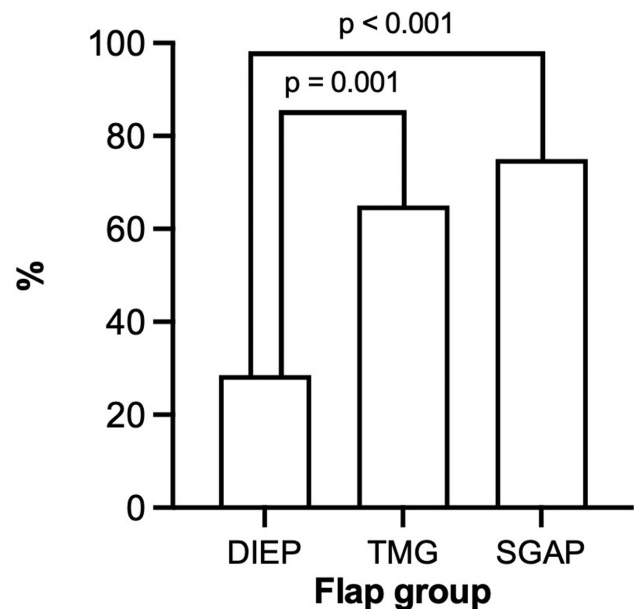
## Results

### Demographics

A total of 242 free flap breast reconstructions were performed in 189 patients (►Table 1). This included 183 DIEP flaps (75.6%), 28 SGAP flaps (11.6%), and 31 TMG flaps (12.8%). Two patients received revision reconstructions with a different flap type. The mean age of the patient cohort was 53.3 years (range: 27–78 years), and the mean BMI of 24.2 kg/m<sup>2</sup> (range: 16.4–38.3 kg/m<sup>2</sup>) with only 11.0% of patients ( $n=21$ ) was showing a value of greater than or equal to 30.0 kg/m<sup>2</sup>. A small number of patients had diabetes mellitus ( $n=3$ ) or were smokers ( $n=17$ ). In 22 patients, neoadjuvant chemotherapy had been performed within 8 weeks prior to reconstruction. Demographic data were found statistically comparable between the three flap cohorts, except for BMI.

### Frequency of Donor Site Seroma Formation

A total of 38.2% ( $n=73$ ) patients developed seroma at the donor site and 28.6% ( $n=42$ ) of patients in the DIEP group



**Fig. 1** Frequency of seroma formation at the DIEP, TMG, and SGAP donor site shown in percentages. A significant difference in seroma formation was observed between the DIEP (28.6%) and the TMG (65.0%) group ( $p=0.001$ ) and between the DIEP (28.6%) and SGAP (75.0%) group ( $p<0.001$ ). No significant difference was observed between the SGAP and the TMG group. DIEP, deep inferior epigastric perforator; SGAP, superior gluteal artery perforator; TMG, transverse musculocutaneous gracilis.

developed seroma, as opposed to 65.0% ( $n=13$ ) in the TMG group and 75.0% ( $n=18$ ) in the SGAP group (►Fig. 1). A subtable analysis revealed a significant difference in the rate of seroma formation between the DIEP and SGAP groups ( $p<0.001$ ) and between the DIEP and TMG group ( $p=0.001$ ). However, no significant difference was observed between the SGAP and the TMG group ( $p=0.469$ ).

### Associated Factors of Seroma Formation

Fischer's exact test showed no association between seroma formation at the donor site and the following parameters: BMI ( $p=0.337$ ), age at surgery ( $p=0.952$ ), smoking status ( $p=0.803$ ), presence of diabetes mellitus ( $p=0.334$ ), neoadjuvant chemotherapy ( $p=0.309$ ), and DIEP laterality (unilateral or bilateral;  $p=0.393$ ; ►Table 2). As none of the

**Table 1** Demographic characteristics for patients and by type of flap

	All patients	DIEP (%)	TMG (%)	SGAP (%)	$p$ -Value
No.	189	147	20	24	–
Mean age $\pm$ SD (y)	53.26 $\pm$ 10.69	53.95 $\pm$ 10.60	53.30 $\pm$ 11.93	48.96 $\pm$ 9.51	0.134
Mean BMI $\pm$ SD (kg/m <sup>2</sup> )	24.17 $\pm$ 4.10	25.05 $\pm$ 4.02	22.65 $\pm$ 3.31	20.04 $\pm$ 1.55	<0.001
Current smoker ( $n$ )	17	14	1	2	1.000
Diabetes mellitus ( $n$ )	3	3	0	0	1.000
Neoadjuvant chemotherapy ( $n$ )	22	16	2	4	0.675
Immediate reconstruction ( $n$ )	110	81	15	14	0.239

Abbreviations: BMI, body mass index; DIEP, deep inferior epigastric perforator; SD, standard deviation; SGAP, superior gluteal artery perforator; TMG, transverse musculocutaneous gracilis.

**Table 2** Analysis of potential associations with seroma formation (univariate logistic regression)

Parameter	OR	p-Value	95% CI
BMI	0.96	0.337	[0.90, 1.04]
Age	1.00	0.952	[0.97, 1.03]
Current smoker	0.88	0.803	[0.31, 2.48]
Diabetes mellitus	3.30	0.334	[0.29, 37.01]
Neoadjuvant chemotherapy	0.60	0.309	[0.22, 1.61]
Unilateral versus bilateral DIEP flap	0.70	0.393	[0.31, 1.58]
Immediate versus delayed reconstruction	1.09	0.773	[0.31, 1.58]

Abbreviations: BMI, body mass index; CI, confidence interval; DIEP, deep inferior epigastric perforator; OR, odds ratio.

analyzed factors were significant, no multivariable analysis of the parameters was performed. In the case of diabetes mellitus, a higher risk of seroma formation was observed with an odds ratio (OR) of 3.3, however, without statistical significance. Additionally, an ROC analysis was conducted to identify a possible cut-off point for age at surgery and BMI at which the risk of seroma formation increased significantly. Neither age (AUC = 0.509,  $p = 0.829$ ) nor BMI (AUC = 0.547,  $p = 0.294$ ) showed prognostic properties for seroma formation. In the case of BMI, the Youden index calculated a cut-off point at  $\leq 21.6 \text{ kg/m}^2$  for an increased risk of seroma formation; however, as mentioned above, no significant association with seroma formation was observed.

**Number of Seroma Evacuations**

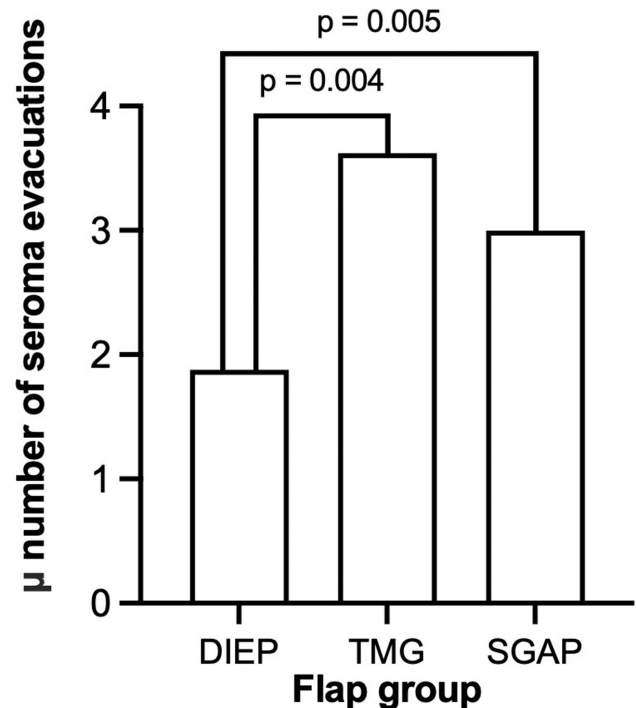
If seroma occurred, the first evacuation took place 20.8 days after surgery on average. The mean number of evacuations in all three flap groups was 2.5 times. The individual means for the three donor sites were: 1.9 times for DIEP flaps (median = 1.00 [IQR: 1.00–2.00]), 3.0 times for SGAP flaps (median = 3.00 [IQR: 2.00–4.00]), and 3.6 times for TMG flaps (median = 3.00 [IQR: 2.00–4.00]; ▶Fig. 2). A Kruskal–Wallis test showed a significant difference for the number of seroma evacuations between the three donor sites ( $p = 0.007$ ). A post hoc analysis demonstrated a significant difference between the DIEP and SGAP group ( $p = 0.004$ ), as well as the DIEP and TMG group ( $p = 0.005$ ). However, no significant difference in the number of seroma evacuations was found between the SGAP and TMG group ( $p = 0.416$ ).

**Discussion**

In this study, we observed a significant difference in the frequency of donor site seroma formation between the DIEP flap and the TMG or SGAP flaps. The rate of seroma formation was lowest at the DIEP flap donor site.

As to the DIEP flap, varying rates of seroma formation have been reported in literature. According to a systematic review by Lindenblatt et al, these range from 1 to 48%.<sup>7</sup> Our value of 28.6% lies within this reported range. The varying rates could be explained by the differing definitions of seroma between the studies. While Xu et al defined seroma/hematoma as any fluid collection that required further intervention and showed a seroma rate of 0.9%,<sup>8</sup> our study included all fluid

collections that were clinically palpable or visualized by ultrasonography, independent of the necessity for intervention. This could explain the higher rate observed in this study. Of note, our analysis of 183 DIEP flaps constitutes one of the largest datasets on seroma formation at this donor site. Regarding the TMG group, a systematic review and pooled analysis conducted by Lakhiani et al revealed seroma rates between 0.4 and 2.0%.<sup>9</sup> These values differ strongly from our observed frequency of 65.0%. Less-extensive research has been conducted on seroma formation at the SGAP flap donor site. Our analysis showed the highest frequency of seroma formation (75.0%) compared with data from literature



**Fig. 2** Mean number of seroma evacuations in the DIEP, TMG, and SGAP donor site. A significant difference in the mean number of seroma evacuations was observed between the DIEP (mean number = 1.9) and the TMG (mean number = 3.6) group ( $p = 0.005$ ) as well as the DIEP (mean number = 1.9) and the SGAP (mean number = 3.0) group ( $p = 0.004$ ). No significant difference was observed between the SGAP and the TMG group. DIEP, deep inferior epigastric perforator; SGAP, superior gluteal artery perforator; TMG, transverse musculocutaneous gracilis.

(values between 2 and 35%).<sup>10,11</sup> The low value of 2% reported by Guerra et al cannot be compared with our data as the study did not make clear how seroma was defined and whether only seroma that required further intervention was included.<sup>11</sup>

Abdominally based flaps tend to be the first choice in autologous breast reconstruction. However, in individuals with little abdominal tissue or previous surgery with abdominal scarring, a different donor site might be considered. A potential explanation for the higher seroma rates in the TMG and SGAP groups could be related to the lower BMI of these patients. A low BMI may be caused by illness or malnutrition. Many cancer patients suffer from malnutrition and cachexia due to a tumor-related mechanism.<sup>12,13</sup> These patients potentially also have a lower preoperative albumin level which increases their risk of seroma formation significantly.<sup>14</sup> Unfortunately, preoperative albumin values were not routinely collected in our patient cohort.

No significant association was found between various factors and seroma formation. The lack of any association between BMI and seroma formation is in line with previous findings by Modarressi et al.<sup>15</sup> In contrast, several other studies have reported an association between BMI and seroma formation.<sup>16–20</sup> This difference might be explained by the fact that the mean BMI was comparably low in our patient cohort, with only 11.0% of patients ( $n = 21$ ) showing a BMI equal to or larger than 30.0 kg/m<sup>2</sup>. In contrast, the study by Fischer et al included a population with a mean BMI of 28.4 kg/m<sup>2</sup>, whereby 33.5% of patients had a BMI equal to or greater than 30.0 kg/m<sup>2</sup>, and reported an increased risk of minor complications (including seroma) in patients with a higher BMI. Interestingly, our ROC analysis revealed a cut-off of  $\leq 21.6$  kg/m<sup>2</sup> for an increased risk of seroma formation. Although this was not statistically significant, it is an interesting finding. As mentioned above, the SGAP and TMG flaps are chosen at our center in patients who tend to have a lower BMI value and presumably have lower preoperative serum albumin values, increasing their risk of seroma formation.<sup>14</sup> As to age at surgery, smoking status, diabetes mellitus, and neoadjuvant chemotherapy numerous studies have concluded that there is no significantly higher risk of seroma formation linked to the factors, which corresponds to our findings.<sup>15–17,21</sup> It must be stated, however, that some of these studies did not analyze seroma as a donor site complication separately but rather as part of a group of possible complications (mostly in the form of minor complications). Additionally, the low incidence of smokers ( $n = 17$ ) and diabetics ( $n = 3$ ) in our study is a limiting factor. We furthermore compared the rate of seroma formation between unilateral and bilateral DIEP flaps. Whereas we found a reduced risk of seroma formation in the unilateral group with an odds ratio of 0.70, this was not statistically significant ( $p = 0.393$ ). However, we found no literature regarding this research question. Additionally, pressure dressings have been described as an effective measure to reduce the occurrence of postoperative seroma.<sup>22</sup> Moreover, literature does not uniformly agree on the effect of the dissection type

(sharp vs. electrocautery vs. ultrasonic dissection) on seroma formation.<sup>23–25</sup> These aspects could be further evaluated in future studies.

This study observed a significant difference in the number of seroma evacuations between the three flap donor sites. For the DIEP flap, a mean number of 1.9 evacuations was found. Similarly, an average of two evacuations was reported by Nedomansky et al.<sup>5</sup> Higher values up to an average of 11 evacuations have been reported by Sadeghi et al.<sup>19</sup>. However, no literature was identified regarding the SGAP and TMG flaps, marking the data in this comparative analysis as a new finding.

Given the high frequency of seroma formation in our study, the necessity to adapt the surgical protocol becomes evident. Numerous methods to prevent postoperative seroma have been reported by Janis et al, including progressive tension sutures.<sup>26</sup> Pollock and Pollock and Sforza et al have also proposed the use of progressive tension or quilting sutures to reduce the risk of seroma formation in abdominoplasty.<sup>27,28</sup> Whereas Sforza et al placed a small number of quilting sutures, the study conducted by Warner and Gutowski described the use of barbed progressive tension sutures. Both methods did not prolong operating time, yet still showed the advantage lower seroma rates.<sup>28,29</sup> Barbed progressive tension sutures have been proven to be a safe alternative to traditional closure with drain placement in the case of DIEP donor site closure and this technique also resulted in reduced total abdominal drainage.<sup>30,31</sup> The use of barbed progressive tension sutures without drain placement could further increase patient comfort and reduce the risk of seroma formation.<sup>29</sup>

This study has some limitations. First, the number of flaps were not uniformly distributed between the three flap types. Also, seroma was diagnosed by different care providers, including plastic surgeons, as well as breast surgeons. Hence, interobserver variability might have led to bias. Additionally, a retrospective evaluation of the number of days, a drain was left in after surgery was not possible. However, in the senior of surgeon's practice, drains were removed when the delivery rate went below 30 mL/24 h. This is in accordance with a large meta-analysis conducted by Salgarello et al.<sup>32</sup>

This study provides a single center's experience regarding seroma formation at three commonly used free flap donor sites for autologous breast reconstruction based on a large set of patients. We observed a significant difference in the rate of donor site seroma formation between the DIEP flap and the TMG or SGAP flaps. To our knowledge, this is the first study providing data regarding the number of seroma evacuations at the TMG or SGAP flap donor site. In view of the high number of observed seromas, barbed progressive tension sutures could be a safe alternative for closure compared with traditional closure and drain placement. The authors plan to establish this technique at their center, aiming to perform a further quality assessment in the near future.

#### Author Contributions

A.M. performed data collection, statistical analysis, and drafted and revised the manuscript. N.E.S. assisted in

designing the project and wrote all drafts and revisions. M.M. performed statistical analysis and assisted to revise the manuscript. D.J.S. assisted to revise the manuscript. J. F. designed the project of this article and assisted to write all drafts and revisions. All authors read and approved the final manuscript.

#### Ethical Approval

All procedures performed within this study were in accordance with the ethical standards of the institutional and national research committee, as well as with the 1964 Helsinki Declaration and its later amendments. Given that this study was conducted in the context of an audit as part of a quality improvement assessment, no specific approval was needed, as confirmed by the local medical ethics committee (BASEC-Nr. 2020-00609).

#### Patient Consent

The patients provided written consent in accordance with institutional policies.

#### Funding

None.

#### Conflict of Interest

J.F. is an editorial board member of the journal but was not involved in the peer reviewer selection, evaluation, or decision process of this article. No other potential conflicts of interest relevant to this article were reported.

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