Journal of Plastic, Reconstructive & Aesthetic Surgery xxx (xxxx) xxx

JPRAS
An International Journal of Surgical Reconstruction
www.JPRASurg.com

Midline epigastric scars can be associated with higher umbilical complications following DIEP flap harvest

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Received 20 April 2021; accepted 9 January 2022
Available online xxx

KEYWORDS
Diep inferior epigastric perforator;
DIEP flap;
DIEP flap breast reconstruction;
Breast reconstruction;
Umbilicus;
Umbilical necrosis

Summary *Background:* Umbilical complications can be relatively common after breast reconstruction with deep inferior epigastric perforator (DIEP) flaps. The medial umbilical ligaments and the ligamentum teres hepatis can be the sole blood supply to the umbilicus after a DIEP flap harvest. Prior incisions along the epigastric midline may disrupt the ligamentum teres hepatis. In this retrospective study, we assess the influence of previous midline epigastric scars on umbilical complications after DIEP flap harvest.
Methods: All patients who underwent breast reconstruction with DIEP flaps were identified at an academic institution over six years. Relevant sociodemographic and clinicopathologic factors were reviewed in the electronic medical records. Univariate and multivariate analyses were performed to determine the role of clinical variables to predict the chance of umbilical complications.

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https://doi.org/10.1016/j.bjps.2022.01.023

Please cite this article as: J.H. Yang, S. Colakoglu, M.A.M. Mureau et al., Midline epigastric scars can be associated with higher umbilical complications following DIEP flap harvest, Journal of Plastic, Reconstructive & Aesthetic Surgery, https://doi.org/10.1016/j.bjps.2022.01.023

Results: A total of 243 patients met inclusion criteria, with 39 patients (16%) having prior surgery utilizing midline epigastric incisions. Twenty-one patients had umbilical complications. No significant difference in patient characteristics was found between patients with and without prior midline epigastric scars. Patients with a history of previous midline epigastric scars had a higher rate of umbilical complications (20.5% vs. 6.4%, $p < 0.01$). Bilateral medial row perforator-based DIEP flap harvest was also related to a higher rate of umbilical complications (18.4% vs. 6.2% $p < 0.01$).

Conclusion: Previous midline epigastric scars are associated with higher rates of umbilical complications after DIEP flap harvest. Bilateral medial row perforator-based DIEP flap harvest exacerbates the rate of umbilical complications and should be avoided in patients with prior midline epigastric incision whenever possible.

Introduction

Deep inferior epigastric perforator (DIEP) free flap has become the gold standard of autologous breast reconstruction in recent years owing to its many advantages over other types of flap reconstruction, including less impairment to daily function with preservation of core muscles[1-3] and higher patient satisfaction with more natural results.[4-6] Despite these benefits, donor site morbidity is not uncommon after DIEP flap harvest and can significantly impact surgical outcomes.[7,8] Umbilical reposition is a necessary component of donor side closure, and as such, an untoward outcome that can negatively influence recovery is umbilical complications. For example, suboptimal aesthetic results and wound healing-related complications can occur.[9] Cho et al. retrospectively reviewed 323 patients who underwent DIEP flap reconstruction and reported an umbilical complication rate of 18%.[10] The extensive vascular disruption of the umbilicus and its surroundings may be the culprit for this relatively high complication rate.

The umbilicus has three sources of deep blood supply in addition to the subdermal plexus. First is the bilateral deep inferior epigastric arteries, followed by small vessels through the ligamentum teres hepatis and medial umbilical ligaments.[11] The medial umbilical ligament carries the umbilical artery during fetal life and typically obliterates in adulthood. During a DIEP flap harvest, repositioning of the umbilicus requires a circumferential incision that leads to the disruption of the subdermal plexus. Additionally, utilizing medial row perforators for both hemiabdomen flaps during bilateral or stacked DIEP flap harvest theoretically only leaves the small vessels through the falciform ligament as the sole blood supply to the umbilicus.

The falciform ligament is a structure that runs craniocaudally along the anterior surface of the liver, providing an important anatomical landmark for laparoscopic surgeries.[12] The ligamentum teres hepatis travels within the free inferior portion of the falciform ligament and connects the liver to the ventral abdominal wall.[13] Although utilization of the falciform ligament as a vascularized flap for management of duodenal ulcer perforation has been described, it has long been thought of as an insignificant embryological remnant and sacrificed liberally with little consequence.[14-16] Because injury to the falciform ligament has no clinical significance, no studies report the incidence of falciform ligament injuries after open or laparoscopic surgeries. In fact, division of the falciform ligament has been suggested for increasing exposure during laparoscopic cholecystectomy.[17]

Prior studies have generally not shown any significant correlation between having surgical scars on the abdomen and a higher rate of DIEP flap complications.[18] Laporta et al. found that in DIEP patients with previous abdominal scars (including Pfannenstiel, subcostal, midline, Mcburney, laparoscopic, and others), there was no significant difference in donor site complication rates compared to patients without abdominal scars. Similarly, Roostaeian et al. reported that prior open abdominal surgery had no impact on the overall donor site complication rate in abdominal-based free flaps reconstruction. However, subgroup analysis revealed a significantly higher rate of delayed wound healing in the scar group than the control group (2.99% vs. 0.37%, $p = 0.004$).[19] Additionally, Parrett et al. demonstrated that prior abdominal scars did not affect flap necrosis rate for patients undergoing DIEP flap breast reconstruction, but it did relate to a higher rate of donor site complications. However, this study did not examine umbilical outcomes.[20] To the best of our knowledge, no study has explicitly focused on previous abdominal scar's impact on umbilical vascular supply and the subsequent complications after DIEP flap harvest. Perforator row location in DIEP flap harvest also plays a role in complications. Medial row perforator harvest is associated with fat necrosis, and lateral row perforator harvest is associated with bulge and hernia formation.[21,22] Despite that, no study demonstrated the impact of perforator row location on umbilical complications.

Given the diminished vascular supply of the umbilicus following DIEP flap harvest, we retrospectively investigated the influence of patient characteristics, perforator row location, and previous abdominal surgeries with a high risk of falciform ligament injury on the occurrence of umbilical complications. We hypothesized that patients with previous midline epigastric scars that are high risk for falciform ligament injury would carry the highest risk of umbilical complications, especially when bilateral medial row perforators are harvested for DIEP flap breast reconstruction.

Methods

All patients who have undergone DIEP free flap breast reconstruction at UCHealth University of Colorado Hospital from January 2014 to March 2020 were identified. A retrospective chart review was performed after obtaining approval by the Institutional Review Board at University of Colorado Hospital (reference number 19-1564).

Electronic medical records were reviewed for patient demographics, including age, ethnicity, race, comorbidities, smoking status, chemotherapy, and radiation therapy history. Relevant information was collected through reviewing clinical and operative notes. Post-operative complications were gathered through post-operative progress notes, discharge summaries, and clinic notes within 90 days of DIEP flap breast reconstruction.

Prior surgical information was recorded by evaluating past surgical histories and any scar identification in plastic surgery pre-operative or operative notes. Also, whenever available, the pre-operative photo of the patient's abdomen was reviewed for evidence of scar in the area of interest. We recorded scars involving the subcostal region and the midline of the abdomen superior to the umbilicus and inferior to the xiphoid process. Operations with high utilization of midline upper abdominal port placement, including laparoscopic cholecystectomy, hiatal hernia repair, gastric bypass, and gastric sleeve surgeries were specifically searched in the online medical records.

Umbilical complications were recorded, including partial and complete umbilical necrosis, umbilical wound dehiscence, and umbilical infections. Infection was defined as any umbilical abnormality treated with prescribed oral or intravenous antibiotics. Abdominal site complications were recorded separately from umbilical complications.

Statistical analysis

Categorical variables were expressed as frequencies and percentages (%). Continuous variables were expressed as mean $\pm$ standard deviation (SD). The Shapiro-Wilk test was used to assess the normality assumption for the continuous variables. The differences in proportions between the group with no prior midline epigastric scar (control group) and the group with prior midline epigastric scar (scar group) were compared using chi-square or Fisher's exact tests as appropriate. Student's *t*-test was used to compare continuous variables in the two independent groups. Odds ratios (95% confidence intervals) of the independent clinical parameters were calculated with univariate and multiple logistic regression models to predict the presence of umbilical complications. A multiple logistic regression analysis was built by performing stepwise variable selection on those variables with a univariate p-value < 0.25. The Hosmer and Lemeshow test was computed to detect goodness of fit in the multiple logistic regression models, and a non-significant p-value indicated a good fit. All statistical analyses were conducted using SPSS 19.0 for Windows Version 19.0 software (IBM Corp., Armonk, NY, USA). All p-values of less than 0.05 were considered to indicate statistical significance.

Results

A total of 243 patients have undergone DIEP free flap breast reconstruction between January 2014 and March 2020 and met the inclusion criteria. Thirty-nine (16%) patients had prior midline epigastric scars. No significant difference in patient characteristics was found between the scar and control groups (Table 1).

Umbilical complications occurred significantly more often in the scar group compared to the control group (20.5% vs. 6.4%, $p < 0.01$). Further classification found a significantly higher rate of umbilical dehiscence in the scar group versus the control group (10.3% vs. 1.0%, $p < 0.01$). There was no statistically significant difference in the occurrence of umbilical infection and necrosis and other abdominal complications between the scar and control group on subgroup analysis (Table 2).

There was no significant difference in the use of bilateral medial row perforators between patients with and without midline epigastric scars (23.1% vs. 19.6%, $p = 0.62$) (Table 1). However, bilateral medial row-based flap harvest was associated with a higher rate of umbilical complications (18.4% vs. 6.2%, $p < 0.01$). Patients with prior midline upper abdominal incisions and bilateral medial row-based flap harvest had a umbilical complications rate of 55.6%, significantly greater than patients who also had epigastric scars but without bilateral medial row-based flap harvest (10.0%, $p < 0.01$) (Table 3).

Univariable and multiple logistic regression analyses were performed to determine the role of distinct clinical variables to predict the chance of umbilical complications (Table 4). Univariable analysis revealed that a 1 kg/m^2 increase in body mass index was associated with 1.16 times increased likelihood of an umbilical complication. No significant univariable association was observed with age, immunosuppression use, diabetes mellitus, perioperative chemotherapy, neoadjuvant chemotherapy, and adjuvant chemotherapy. Having bilateral medial row perforator-based flap harvest and midline upper abdominal scars increased the likelihood of umbilical complications by 3.4 and 3.8 times, respectively. Multiple logistic regression analysis was also performed. The Hosmer-Lemeshow goodness of fit test was not significant ($p = 0.62$). Body mass index, bilateral medial row perforator usage, and presence of a midline epigastric scar remained significant predictors in the analysis with increase in the odds of umbilical complications by 1.141 (95% CI 1.04-1.25), 2.905 (95% CI 1.08-7.79), and 3.338 (95% CI 1.22-9.14) times, respectively (Table 4).

Discussion

The umbilicus is an important structure of the abdomen contributing significantly to abdominal aesthetics. Numerous umbilicoplasty techniques have been described in the literature, aiming to recreate the perfect umbilicus.[23] When the umbilicus does not heal properly, it can lead to prolonged wound care with additional clinical visits, and suboptimal aesthetics that can ultimately decrease patient satisfaction.[24] Understanding risk factors associated with umbilical complications after DIEP free flap harvest can minimize

Table 1 Patient characteristics.

	Control group ($N = 204$)	Scar group ($N = 39$)	P-values
Age, years (mean ± SD)	49.71 ± 10.26	51.20 ± 10.47	0.45
Body mass index, kg/m^2 (mean ± SD)	28.85 ± 4.82	29.53 ± 4.40	0.07
Race			
Non-Hispanic white	160 (78.4%)	31 (79.5%)	0.92
African American	9 (4.4%)	1 (2.6%)	
Asian and Pacific Islander	9 (4.4%)	1 (2.6%)	
American Indian	3 (1.5%)	0	
Hispanic	23 (11.3%)	6 (15.4%)	
Perforator Row			
No medial row perforator-based harvest	164 (80.4%)	30 (76.9%)	0.62
Bilateral medial row perforator-based harvest	40 (19.6%)	9 (23.1%)	
Bilateral medial row perforators	40 (19.6%)	9 (23.1%)	0.11
Bilateral lateral row perforators	46 (22.5%)	10 (25.6%)	
Unilateral medial row perforators	39 (19.1%)	5 (12.8%)	
Unilateral lateral row perforators	38 (18.6%)	2 (5.1%)	
One side medial one side lateral row perforators	41 (20.1%)	13 (33.3%)	
Perioperative chemotherapy	3 (7.7%)	19 (9.3%)	0.75
Neoadjuvant chemotherapy	9 (4.4%)	3 (7.7%)	0.39
Adjuvant chemotherapy	10 (4.9%)	0	0.16
Comorbidities			
Diabetes mellitus	13 (6.4%)	2 (5.1%)	0.77
Smoking	67 (32.8%)	11 (28.2%)	0.57
Immunosuppressive medication use	2 (1.0%)	2 (5.1%)	0.12

SD: standard deviation.

Table 2 Rate of complications in control vs. scar group.

	Control group ($N = 204$)	Scar group ($N = 39$)	P-value
Umbilical complication	13 (6.4%)	8 (20.5%)	0.01
Umbilical infection	5 (2.5%)	1 (2.6%)	0.97
Umbilical necrosis	6 (2.9%)	3 (7.7%)	0.60
Umbilical wound dehiscence	2 (1%)	4 (10.3%)	0.01
Other donor site complications			
Bulge	28 (13.8%)	5 (12.8%)	0.88
Hernia	4 (2%)	2 (5.1%)	0.25
Fluid collection	10 (4.9%)	2 (5.1%)	0.54
Hematoma	2 (1%)	0	0.99
Seroma	8 (3.9%)	2 (5.1%)	0.67
Wound dehiscence	24 (11.8%)	9 (23.1%)	0.06
Infection	22 (15.4%)	6 (10.4%)	0.41

Table 3 Control vs. scar group rate of umbilical complications in the setting of bilateral medial row-based flap harvest.

		No Umbilical complication ($N = 222$)	Umbilical complication ($N = 21$)	P-value
	Bilateral medial row	40 (81.6%)	9 (18.4%)	0.01
	Non-bilateral medial row	182 (93.8%)	12 (6.2%)	
Scar group	Bilateral medial row	4 (44.4%)	5 (55.6%)	0.01
	Non-bilateral medial row	27 (90%)	3 (10%)	
Control group	Bilateral medial row	36 (88.9%)	4 (11.1%)	0.30
	Non-bilateral medial row	155 (92.8%)	12 (7.2%)	

Table 4 Univariable and multivariable analyses.

Risk factors	Umbilical complication				
	Univariable analysis		Multivariable analysis		
	P-value	OR	P-value	OR	95% CI
Age	0.88	1.000			
BMI	0.01	1.16	0.01	1.14	1.04-1.25
Immunosuppressive medication use	0.27	3.65			
Diabetes mellitus	0.78	1.36			
Perioperative chemotherapy	0.94	1.06			
Neoadjuvant chemotherapy	0.97	1.04			
Adjuvant chemotherapy	0.86	1.01			
Bilateral medial row perforator harvest	0.01	3.41	0.03	2.91	1.08-7.79
Midline epigastric scar	0.01	3.79	0.02	3.34	1.22-9.14

adverse patient outcomes and positively impact patient satisfaction.

Many studies regarding prior abdominal scars and their impact on abdominal-based free flap breast reconstruction have focused on flap complications and donor site morbidity without including umbilical complications.[19,20,25] Studies that focused on umbilical complications following abdominal-based free flap harvest for breast reconstruction have found several risk factors, including patient characteristics such as age and body mass index, comorbidities such as smoking and hypertension, as well as physical dimensions such as stalk height and flap weight.[9,10] Our results also support body mass index to be associated with higher umbilical complication rates. Interestingly, the previous studies mentioned above found no significant association between a history of prior abdominal surgery and umbilical complications. Perhaps, the main drawback of these studies was the inclusion of all prior scars throughout the entire abdomen from the subcostal region superiorly to the pubic region inferiorly. Such inclusion criteria may be too broad and do not direct the question at specific vascular territories that critically influence post-operative recovery and outcomes. In our study, we concentrated on prior surgeries that have a high risk of injuring one of the remaining blood supply sources of the umbilicus, the ligamentum teres hepatis, which can potentially affect wound healing. Our analysis confirmed our hypothesis since we have shown that the presence of a prior midline epigastric scar is correlated with increased umbilical complications, which in turn suggests that vascular disruption of the ligamentum teres hepatis can affect recovery leading to worse wound healing.

Furthermore, we have demonstrated that bilateral medial row perforator-based flap harvest is associated with a higher rate of umbilical complications. This could be related to the fact that medial DIEP are likely supplying the umbilicus, and if taken bilaterally, the umbilical blood supply is significantly disrupted. The umbilical complication rate was even higher when our analysis was concentrated on bilateral medial row perforator harvest in patients with prior midline epigastric scars. This is not surprising since in these cases the vascular supply disruption is even more extensive given the fact that both medial deep inferior epigastric vessels and most likely the ligamentum teres hepatis have been compromised. Prior authors have shown that the DIEP system offers on average 6.4 perforator vessels per flap that can be used to elevate the flap.[26] The choice of perforators, whether medial or lateral, can significantly affect flap design and harvesting.[27] The selection of medial or lateral row perforators has been associated with different complications, such as fat necrosis, bulges, and hernias.[21,22] Our findings provide more information as it relates to the selection of the appropriate row of perforators during flap harvest for patients with prior midline epigastric scars. For instance, if feasible, the surgeon should try to preserve at least the perforators from one of the medial rows to decrease the chances of an umbilical complication.

If we assume that decreased vascular perfusion may be associated with umbilical complications, imaging modalities evaluating vascular anatomy can be useful in improving surgical outcomes. Computed tomography angiography (CTA) is commonly used for pre-operative perforator mapping in DIEP reconstruction. In fact, it has been shown to assist in identifying vascular anatomy, thus supporting surgical planning and reducing overall operative times.[28-30] The use of CTA has also been found to reduce risk of partial necrosis and flap loss in DIEP reconstruction.[31] Based on the above, it is advisable that CTA is obtained for all patients with prior midline epigastric scars as it can help with perforator row selection and perhaps avoid bilateral medial row-based flap harvest in order to reduce risk of umbilical complications. If bilateral medial row harvest is found to be necessary, patients should be properly educated regarding the increased risk of complications and the possible remedies, so an informed decision can be made. Another imaging modality that may be useful intraoperatively is indocyanine green (ICG) with laser angiography. The use of ICG fluorescent angiography has been shown to significantly increase perfusion rate of flaps.[32] Low perfusion scores identified through imaging program associated with ICG fluorescent angiography can be predictive of mastectomy flap necrosis with a sensitivity of 88%.[33] Relating to our findings, ICG fluorescent angiography can be beneficial in reporting the real-time perfusion to the umbilicus intraoperatively and allow the surgeon to make a better informed decision about umbilical preservation. One could argue that the umbilicus can be sacrificed in some high risk scenarios if intraoperative imaging suggests that the umbilical blood supply is completely compromised. Such an approach may avoid postoperative is-

sues with umbilical healing that may prolong recovery, with plans for elective umbilicoplasty in the future.

There are several limitations to this study that need to be addressed. Because of the retrospective study design, data were limited to recorded information in the electronic medical records, and some pertinent data such as past surgical history may not be complete. Also, there may be variation in the level of detail among different providers' notes due to individual preferences. There may also be underreporting of minor umbilical complications by patients, especially if the issue is resolved between clinic visits. Moreover, limitations exist when reviewing pre-operative photos, as the scars may not be visualized and recorded due to image quality or excellent healing. It is also uncertain whether the midline epigastric scars included in this study correlate with a definitive falciform ligament injury. Operative variations such as umbilicoplasty technique and suture selection may exist. Factors reported to influence umbilical complications in prior studies such as umbilical stalk height and procedure time were not examined in this study and may have confounding effects. The sample size of this study is relatively small. With data from a single academic center, there may be limitations in patient demographics such as socioeconomic status and racial demographic; therefore, data may not be generalizable to the public.

Conclusions

Prior midline epigastric scars are associated with a higher risk of umbilical complications after a DIEP free flap harvest, particularly affecting umbilical wound dehiscence. Bilateral medial row perforator-based flap harvest increases the rate of umbilical complications and should be avoided in patients with prior midline epigastric scar whenever possible. Perhaps, the pre-operative CT angiography outlining vascular anatomy may help ensure targeted flap harvest that reduces the risk of umbilical complications in this patient population, or at least assist with pre-operative patient education as it relates to the expected rate of umbilical complications and recovery.

Declaration of Competing Interest

The authors have no conflicts of interest to disclose.

Disclosure

The authors have no financial interests in this research project or in any of the techniques or equipment used in this study.

Ethical approval

Approval has been obtained by the Institutional Review Board at University of Colorado Hospital (Reference number: 19–1564).

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