Does Fitzpatrick Score Predict Flap Loss? Microsurgical Breast Reconstruction Outcomes of Varying Skin Color

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**Background:** The aim of this study was to seek evidence that patients with darker Fitzpatrick score skin tones are more susceptible to flap loss due to unsalvaged vascular compromise in autologous flap breast reconstruction.

**Methods:** This is a retrospective study conducted on patients who underwent any type of autologous flap breast reconstruction performed by the two senior authors at an academic center between January 2010 and December 2021. The sole primary outcome variable was flap loss. Patient skin tone was assessed using the Fitzpatrick scale on clinical photographs of patients.

**Results:** A total of 1115 patients underwent autologous flap breast reconstruction, of which only 56 met both exclusion and inclusion criteria with 58 individual breasts being included in the final study population. The most common race of subjects was White (n = 33; 56.9%) while the most common Fitzpatrick score skin tone was type II (n = 22; 37.9%). The Cochran-Armitage test of trend showed a statistically significant linear trend, \( P = 0.006 \), with darker Fitzpatrick score skin tones associated with a higher proportion of flap loss in patients who had vascular compromise. A logistic regression showed that none of the predictor variables were significant.

**Conclusions:** Patients with darker Fitzpatrick skin tones were associated with flap loss after vascular compromise. To prevent flap loss in patients who have darker Fitzpatrick score skin tones, more aggressive flap monitoring should be taken into consideration in the immediate postoperative setting. (Plast Reconstr Surg Glob Open 2022;10:e4637; doi: 10.1097/GOX.0000000000004637; Published online 7 November 2022.)

**INTRODUCTION**

Autologous breast reconstruction is lauded by both patients and surgeons as the preferred method of breast reconstruction due to its natural aesthetic. The superior aesthetic outcome is mirrored by higher rates of overall patient-reported satisfaction when compared with implants.\(^1,2\) In addition to technical advances in donor site selection, which have broadened the range of body types reconstructive surgeons can care for, changes in legislature have eroded substantial cost barriers, allowing more women to pursue life-changing treatment.\(^3\) Despite the efforts of public health policymakers, the steady rise in reconstruction rates has not been proportional across races, begetting an unfortunate disparity.\(^4,5\) Although there is documentation of disparity in access to care, there remains a lack of literature on patient outcomes based on race or skin tone in reconstructive microsurgery.

The disproportionate number of obstacles that minority patients encounter during the reconstructive process potentially discourages them from seeking reconstruction. Autologous breast reconstruction has scored the worst in terms of racial disparity when compared with other treatment options. Socioeconomic status, another major factor, may also dissuade patients from pursuing autologous reconstruction due to an initially longer hospital stay, longer time off work, and proximity to a plastic surgeon.\(^5,6\) In adjusted analyses, African Americans were less likely to undergo immediate breast reconstruction after mastectomy. Yet, when electing between implants and autologous reconstruction, African Americans are more likely to choose autologous reconstruction when compared with White patients.\(^7\) This trend has been associated with the cultural mistrust of the health care system and foreign objects in the body.\(^7\)

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Systemic disparities in autologous reconstruction implicate a lack of exposure in caring for minorities when compared with White patients, manifesting acute differences in care. The literature is dense with insignificant differences in complication outcomes; however, there has not been a thorough investigation of flap salvage rates regarding skin tone.8,9 There have been multi-institutional studies that have performed extensive research that have not accounted for the role race or skin tone may play in flap salvage outcomes, though they do cement that early take back is a significant predictor of successful salvage. Diverting care back to the operating room to explore a suspected compromise is crucially initiated by effective flap monitoring.10–12 This can be more challenging in darker skin-toned patients,13 as the superficial color change that hallmarks vascular compromise can go unrecognized. Devices and screening modalities have sought to overcome this issue, but their effectiveness has been highlighted in a limited capacity.14,15 Flap-monitoring techniques may fall prey to the same systemic issues that plague the rest of health care, leading to poorer outcomes for minorities.

The aim of this study was to provide evidence that patients with darker Fitzpatrick score skin tones are more susceptible to flap loss due to unsalvaged vascular compromise in autologous flap breast reconstruction. There is also the hope to further discussion on taking increased measures for flap monitoring in patients of darker Fitzpatrick score skin tones.

**MATERIALS AND METHODS**

**Study Design**

This is a retrospective study that was approved by the institutional review board and conducted on patients who underwent any type of autologous flap breast reconstruction performed by the two senior authors at an academic center between January 2010 and December 2021. Patients were excluded from the study if all flaps that were used for reconstruction were either buried or small patch closures, or if flap loss occurred in a flap that was either buried or small patch closure. Inclusion criteria included patients who had postoperative flap compromise due to vascular compromise in the autologous flap (arterial thrombosis, venous thrombosis, unspecified clot, venous insufficiency, or pedicle kink). Patient skin tone was scored using the Fitzpatrick scale and assessed using our flap check protocol. A significant finding using Cochran-Armitage test of trend showed an association of darker skin tones with higher proportion of flap loss.

**Question:** Does skin tone play a factor in flap loss after flap vascular compromise in the postoperative setting?

**Findings:** This study evaluated patients who underwent autologous flap breast reconstruction. Patient skin tone was scored using the Fitzpatrick scale and assessed using our flap check protocol. A significant finding using Cochran-Armitage test of trend showed an association of darker skin tones with higher proportion of flap loss.

**Meaning:** Patients with darker skin tones are associated with higher rates of flap loss due to vascular compromise.

**Takeaways**

**Question:** Does skin tone play a factor in flap loss after flap vascular compromise in the postoperative setting?

**Findings:** This study evaluated patients who underwent autologous flap breast reconstruction. Patient skin tone was scored using the Fitzpatrick scale and assessed using our flap check protocol. A significant finding using Cochran-Armitage test of trend showed an association of darker skin tones with higher proportion of flap loss.

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### Table 1. The Fitzpatrick Scale

| Skin Type | Skin Color | Tanning History |
|-----------|------------|-----------------|
| I         | Light, pale white | Always burns, never tans |
| II        | White, fair    | Usually burns, tans with difficulty |
| III       | Medium white to olive | Sometimes mild burn, gradually tans to olive |
| IV        | Olive tone     | Rarely burns, tans with ease to moderate brown |
| V         | Light brown    | Very rarely burns, tans very easily |
| VI        | Dark brown     | Never burns, tans very easily, deeply pigmented |

A table showing the Fitzpatrick scale we used to analyze skin tones of our patients using clinical photographs. The table has a description of all six skin types.

### Results

A total of 1115 patients underwent autologous flap breast reconstruction, of which only 56 met both exclusion and inclusion criteria with 58 individual breasts being
included in the final study population; flow chart is shown in Figure 1.

The average age and body mass index (BMI) of subjects were 50.95 ± 8.21 and 30.41 ± 6.36, respectively, with no statistical difference between those with and without flap loss. The most common race of subjects was White (n = 33; 56.9%), while the most common Fitzpatrick score skin tone was type II (n = 22; 37.9%). The remaining demographics, comorbidities, family history, cancer treatment, and venous thromboembolism prophylaxis details can be seen in Tables 2 and 3.

There was also no noted statistical significant difference when performing a chi-square analysis in patients who had a flap loss, type of compromise, or take back time group based on Fitzpatrick score skin tone, which can be seen in Tables 4 and 5. Most flap types that were used for breast reconstruction were abdominally based (32; 55.5%). The remaining flap types can be seen in Table 6.

Cochran-Armitage Test of Trend

A Cochran-Armitage test of trend was run to determine whether a linear trend exists between Fitzpatrick score skin tone and the proportion of patients who had flap loss after flap compromise. The Fitzpatrick score skin tones were type I (n = 14), type II (n = 22), type III (n = 2), type IV (n = 6), type V (n = 7), and type VI (n = 7). The proportion of patients with flap loss was 0.214, 0.409, 0.500, 0.500, 0.571, and 0.857, respectively. The Cochran-Armitage test of trend showed a statistically significant linear trend, P = 0.006, with darker Fitzpatrick score skin tones associated with a higher proportion of flap loss. Figure 2 shows a bar graph of the percentage of flap loss within Fitzpatrick score, while Tables 4 and 5 shows the distribution of flap loss within Fitzpatrick score as well as the type of compromise.

Logistic Regression

A binomial logistic regression was performed to ascertain the effects of race, hypertension, diabetes, autoimmune disorder, history of deep venous thromboembolism/pulmonary embolism (DVT/PE), history of miscarriage, family history of hypercoagulability, smoking status, age, BMI, cancer treatment and chemoprophylaxis (Table 3), and take back timing on the likelihood that patients have flap loss. Linearity of the continuous variables with respect to the logit of the dependent variable was assessed via the Box-Tidwell procedure.22 A Bonferroni correction was applied using all 17 terms in the model, resulting in statistical significance being accepted when P is less than 0.00263.23 Based on this assessment, all continuous independent variables were found to be linearly related to the logit of the dependent variable. The logistic regression model was statistically significant, χ²(26) = 79.783, P < 0.001. The model explained 100.0% (Nagelkerke R²) of the variance in flap loss and correctly classified 100.0% of cases. None of the predictor variables were significant, as noted in Table 7.
DISCUSSION

Disparities in plastic surgery have been well documented and show how patients of ethnic and racial minority backgrounds are disproportionately affected. Many of the disparities minority patients face occur in the preoperative setting, such as access to reconstructive care, socioeconomic status, and lack of trust in medical care. To improve on these disparities, it is imperative to study issues that can negatively affect patients of these backgrounds in greater detail. One such disparity that lacks investigation is the postoperative care in patients who receive autologous flap breast reconstruction, specifically assessment of flap compromise.

Independent factors that are associated with flap loss have been well documented in the past. Such factors include history of radiotherapy, history of chemotherapy, intraoperative length, ASA score, smoking status, BMI, and many other patient factors. One factor that has been routinely touched on but not studied in depth has been the impact of Fitzpatrick score skin tones on flap vascular compromise (Figure 3). In the present study, it is shown how patients with darker Fitzpatrick skin tones, specifically type VI (0.857), have a higher proportion of flap loss when compared with those with lighter Fitzpatrick skin tones. This higher rate of flap loss after vascular compromise may be due to the most obvious reason, it is difficult to appreciate skin tone changes that can alert to vascular compromise in those with darker skin tones. As such, more aggressive monitoring of patients with Fitzpatrick skin tone types IV–VI is suggested. Although patients with lighter Fitzpatrick skin tones only had remote numbers of flap loss (type II, 0.409; type III, 0.500; type V, 0.571), the Cochran-Armitage test of trend suggests that as skin tones begin to get darker, there is an increase of flap loss, and thus, it should still warrant aggressive monitoring in patients with darker Fitzpatrick skin tones other than type VI. The authors of this study suggest that this aggressive monitoring should then be performed in patients with Fitzpatrick skin tone types IV–VI. Additionally, while time between the index operation and the take back was not statistically associated with increased likelihood of flap loss, time had a negative correlation with the outcome of flap loss, suggesting that while time between the index operation and the take back was not statistically associated with increased likelihood of flap loss, it had a protective effect on flap viability.
Table 3. Cancer Treatment and Venous Thromboembolism Prophylaxis Details

| Treatment                        | Flap Loss |     |     |     |     | Total |
|----------------------------------|-----------|-----|-----|-----|-----|-------|
|                                  | Yes       | No  |     |     |     |       |
| Neoadjuvant chemotherapy         | Value     | 5   | 14  | 19  |     |       |
|                                  | Percentage| 19.2| 43.8| 32.8|     |       |
| Adjuvant chemotherapy            | Value     | 11  | 11  | 22  |     |       |
|                                  | Percentage| 42.3| 34.4| 37.9|     |       |
| Neoadjuvant hormonal therapy     | Value     | 15  | 21  | 36  |     |       |
|                                  | Percentage| 57.7| 65.6| 62.1|     |       |
| Adjuvant hormonal therapy        | Value     | 3.8 | 6.3 | 5.2 |     |       |
|                                  | Percentage| 12.5| 18.8| 15.9|     |       |
| Preoperative VTE chemoprophylaxis | Value     | 6   | 5   | 11  |     |       |
|                                  | Percentage| 23.1| 15.6| 19  |     |       |
| Postoperative VTE chemoprophylaxis | Value    | 30.8| 56.3| 44.8|     |       |
|                                  | Percentage| 18.6| 45.5| 38.5|     |       |
| Post VTE chemoprophylaxis duration | Value    | 22  | 23  | 45  |     |       |
|                                  | Percentage| 84.6| 71.9| 77.6|     |       |
| Type of compromise               | Arterial thrombosis | Value | 2   | 2   | 0   | 4   |
|                                  | Percentage| 14.3| 9.1 | 0   | 4   |     |
| Venous thrombosis                | Value     | 5   | 12  | 1   | 4   | 26   |
|                                  | Percentage| 35.7| 54.5| 50  | 47.6| 22.6 |
| Both arterial and venous         | Value     | 2   | 0   | 0   | 0   | 4    |
|                                  | Percentage| 21.4| 0   | 0   | 0   | 4    |
| Unspecified clot                  | Value     | 1   | 0   | 0   | 0   | 1    |
|                                  | Percentage| 7.1 | 18.2| 0   | 14.3| 5.7  |
| Venous insufficiency             | Value     | 3   | 0   | 0   | 0   | 5    |
|                                  | Percentage| 21.4| 0   | 0   | 0   | 5    |
| Pedicle kink                     | Value     | 1   | 3   | 0   | 0   | 6    |
|                                  | Percentage| 7.1 | 13.6| 0   | 14.3| 12   |
| Take back timing                 | 0–6 h     | Value | 4   | 2   | 1   | 3   |
|                                  | Percentage| 16.7| 9.1 | 2   | 1   | 12   |
|                                  | 6–12 h    | Value | 2   | 2   | 0   | 2   |
|                                  | Percentage| 35.7| 49.1| 50  | 29.5| 22.6 |
|                                  | 12–24 h   | Value | 5   | 10  | 1   | 2   |
|                                  | Percentage| 35.7| 45.5| 50  | 33.3| 28.6 |
|                                  | 24+ h     | Value | 3   | 6   | 0   | 0   |
|                                  | Percentage| 21.4| 27.3| 0   | 28.6| 19   |
| Discharged                       | Value     | 0   | 2   | 0   | 2   | 4    |
|                                  | Percentage| 0   | 14.3| 0   | 14.3| 8.6  |
| Take backs                       | Value     | 16  | 29  | 2   | 7   | 10   |
|                                  | Percentage| 21.4| 13.6| 1.7 | 1.7 | 1.7  |
| Salvage rate                     | Value     | 81.25| 68.97| 50.00| 57.14| 50.00| 60.50| 63.89|

Table summarizing the cancer treatment and venous thromboembolism prophylaxis care patients who underwent before breast reconstruction, grouped by flap loss status. *P* values were obtained using chi-square test or Fisher exact test with frequencies being reported.

VTE, venous thromboembolism.

Table 4. Flap Compromise Details

| Characteristics                  | Type I | Type II | Type III | Type IV | Type V | Type VI | Total |
|----------------------------------|--------|---------|----------|---------|--------|---------|-------|
| Flap loss                        | Value  | 3       | 9        | 1       | 3      | 4       | 6     |
|                                  | Percentage| 21.4| 49.1| 50  | 50  | 57.1 | 85.7 | 44.8 |
| Type of compromise               | Arterial thrombosis | Value | 2   | 2   | 1   | 1   | 7    |
|                                  | Venous thrombosis    | Value | 5   | 12  | 1   | 4   | 26   |
| Both arterial and venous         | Value     | 2   | 1   | 0   | 0   | 4    |
| Unspecified clot                  | Value     | 1   | 0   | 0   | 0   | 1    |
| Venous insufficiency             | Value     | 3   | 0   | 0   | 0   | 5    |
| Pedicle kink                     | Value     | 1   | 3   | 0   | 0   | 6    |
| Take back timing                 | 0–6 h     | Value | 4   | 2   | 1   | 3   |
|                                  | 6–12 h    | Value | 2   | 2   | 0   | 2   |
|                                  | 12–24 h   | Value | 5   | 10  | 1   | 2   |
|                                  | 24+ h     | Value | 3   | 6   | 0   | 0   |
| Discharged                       | Value     | 0   | 2   | 0   | 2   | 4    |
| Take backs                       | Value     | 16  | 29  | 2   | 7   | 10   |
| Salvage rate                     | Percentage| 81.25| 68.97| 50.00| 57.14| 50.00| 60.50| 63.89|

Tables that summarize flap compromise details based on Fitzpatrick score skin tone. Table 4 details type of take back that occurred, the timing of the take back, and salvage rate based on skin tone.
loss, the increased difficulty with physical examination inherent in darker skin tones could lead to missing more subtle skin changes and result in a delayed return to the operating room.

Handheld Doppler is the mainstay way of monitoring, but most microsurgeons also monitor capillary refill of the skin paddle. The use of the Doppler for monitoring can sometimes mask vascular compromise, as the signal may still be present but weak. That is why combining Doppler with capillary refill is usually a better judge of compromise in flaps. In dark skin tone, these changes can be subtle and difficult to see. Alternative options include implantable Dopplers on venous outflow,26 skin oxygenation monitoring,27 or indocyanine green-fluorescence angiography. 28

Tables that summarize flap compromise details based on Fitzpatrick score skin tone. Table 5 highlights flap loss based on take back timing.  

Table 5. Flap Compromise Details

| Take Back Timing | Type I | Type II | Type III | Type IV | Type V | Type VI | Total |
|------------------|--------|---------|----------|---------|--------|---------|-------|
| 0–6 h Loss       | 3      | 2       | 1        | 1       | 1      | 1       | 9     |
|                  | 33.3   | 22.2    | 11.1     | 11.1    | 11.1   | 11.1    | 100   |
|                  | 1      | 0       | 0        | 0       | 2      | 1       | 3     |
|                  | 33.3   | 0       | 0        | 0       | 66.7   | 0       | 100   |
| 6–12 h Loss      | 1      | 1       | 0        | 1       | 1      | 0       | 4     |
|                  | 25     | 25      | 25       | 25      | 25     | 25      | 100   |
|                  | 1      | 1       | 0        | 0       | 1      | 1       | 3     |
|                  | 25     | 25      | 25       | 25      | 25     | 25      | 100   |
| 12–24 h Loss     | 4      | 7       | 0        | 1       | 1      | 0       | 13    |
|                  | 30.8   | 53.8    | 0        | 77      | 77     | 0       | 100   |
|                  | 1      | 3       | 1        | 1       | 1      | 0       | 2     |
|                  | 11.1   | 33.3    | 11.1     | 11.1    | 11.1   | 22.2    | 100   |
| 24+ h Loss       | 3      | 2       | 0        | 0       | 0      | 0       | 5     |
|                  | 60     | 40      | 0        | 0       | 0      | 0       | 100   |
|                  | 0      | 66.7    | 0        | 0       | 0      | 0       | 33.3  |
| Discharged Loss  | 0      | 1       | 0        | 0       | 0      | 0       | 1     |
|                  | 100    | 0       | 0        | 0       | 0      | 0       | 100   |
|                  | 0      | 1       | 0        | 2       | 0      | 1       | 4     |
|                  | 0      | 25      | 0        | 50      | 0      | 25      | 100   |

Table 6. Flap Type Details

| Flap Type Details | Type I | Type II | Type III | Type IV | Type V | Type VI | Total |
|-------------------|--------|---------|----------|---------|--------|---------|-------|
| Abdominal-based   |        |         |          |         |        |         |       |
| DIEP              | 8      | 9       | 0        | 4       | 5      | 3       | 29    |
| Percentage        | 88.9   | 90      | 0        | 100     | 100    | 75      | 90.6  |
| SADIE             | 1      | 0       | 0        | 0       | 0      | 0       | 1     |
| Percentage        | 11.1   | 0       | 0        | 0       | 0      | 0       | 3.1   |
| SIEA              | 0      | 1       | 0        | 0       | 0      | 0       | 1     |
| Percentage        | 0      | 10      | 0        | 0       | 0      | 0       | 3.1   |
| MSTRAM            | 0      | 0       | 0        | 0       | 0      | 0       | 1     |
| Percentage        | 0      | 0       | 0        | 0       | 0      | 0       | 1     |
| Total             | 8       | 10      | 0        | 5       | 4      | 3       | 32    |
| Percentage        | 64.3   | 45.5    | 0        | 66.7    | 71.4   | 57.1    | 59.5  |
| Leg-based         |        |         |          |         |        |         |       |
| LAP               | 1      | 2       | 0        | 1       | 0      | 1       | 5     |
| Percentage        | 100    | 100     | 0        | 100     | 0      | 100     | 83.3  |
| LTP               | 0      | 0       | 0        | 0       | 1      | 0       | 1     |
| Percentage        | 0      | 0       | 0        | 0       | 1      | 0       | 1     |
| Total             | 8.3    | 9.1     | 0        | 16.7    | 14.3   | 14.3    | 10.3  |
| Percentage        | 5.1    | 5.1     | 100      | 100     | 100    | 100     | 100   |
| Back-based        |        |         |          |         |        |         |       |
| PAP               | 0      | 5       | 1        | 0       | 1      | 1       | 8     |
| Percentage        | 0      | 22.7    | 50       | 0       | 14.3   | 14.3    | 13.8  |
| Stacked/double peddiced | |         |          |         |        |         |       |
| DIEP-SIEA         | 1      | 1       | 0        | 0       | 0      | 0       | 2     |
| Percentage        | 25     | 20      | 0        | 0       | 0      | 0       | 16.7  |
| Double-peddiced DIEP | 0      | 2       | 0        | 0       | 0      | 0       | 2     |
| Percentage        | 0      | 40      | 0        | 0       | 0      | 0       | 16.7  |
| DIEP/PAP          | 1      | 1       | 1        | 1       | 1      | 1       | 4     |
| Percentage        | 25     | 20      | 100      | 100     | 0      | 33.3    | 0     |
| DIEP/LAP          | 1      | 0       | 0        | 0       | 0      | 0       | 2     |
| Percentage        | 25     | 20      | 100      | 100     | 0      | 33.3    | 0     |
| Double PAP        | 1      | 1       | 0        | 0       | 0      | 0       | 2     |
| Percentage        | 35     | 20      | 0        | 0       | 0      | 0       | 16.7  |
| Total             | 4      | 3       | 1        | 1       | 0      | 1       | 12    |
| Percentage        | 33.3   | 22.7    | 50       | 16.7    | 0      | 14.3    | 20.7  |

Flap type details are listed in this table, which groups reconstructions based on type of donor used. Patients were grouped based on Fitzpatrick score skin tone. P values were obtained using chi-square test or Fisher exact test with frequencies being reported. DIEP, deep inferior epigastric perforator; LAP, lumbar artery perforator; LTP, lateral thigh perforator; MSTRAM, muscle-sparing transverse rectus abdominis; PAP, profunda artery perforator; SADIE, superficial inferior epigastric artery-deep inferior epigastric artery; SIEA, superficial inferior epigastric artery.
Another easily implementable protocol is creating a lower threshold for contacting the attending surgeon if there is a change to the flap in patients with darker skin tone. Based on the findings in this study, microsurgeons should consider what additional monitoring options are available in their practice for those patients with darker skin tones.

There have also been improvements made in the techniques and technology for flap salvage, which would be pertinent to briefly touch upon. The mainstay techniques for vascular compromise solely depend on the type of compromise that occurs. Identification of the compromise can be done so with primary measures as previously mentioned, handheld Doppler or capillary refill. In our practice, indocyanine green-fluorescence angiography, a portable fluorescence imaging technology that can visualize blood flow to target areas, has been a useful tool for visualizing vascular compromise. Another tool that may be utilized in flap monitoring is near-infrared spectroscopy, which has shown to have almost 100% sensitivity and specificity for flap compromise. Although this tool has impressive testing capabilities, it contains certain back draws, such as anxiety flap checking, false positives that result in unnecessary take backs, and a certain level of user education.

Ultimately, when vascular compromise does occur, immediate take back is indicated. The primary techniques used once a patient is taken back are mechanical thrombectomy with forceps, thrombolysis with medical agents, hematoma evacuation, or revision of anastomosis of either

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**Fig. 2.** Simple bar graph of patients with flap loss within a Fitzpatrick score group type. The graph illustrates the trend of flap loss based on Fitzpatrick score skin tone. The bars are based on percentage of patients within each Fitzpatrick score group with the number of patients who experienced flap loss at the base of each bar.

**Table 7. Logistic Regression Predicting Likelihood of Flap Loss Based on Covariates**

| Covariates                                | B     | SE    | Wald df | P     | Odds Ratio 95% CI for Odds Ratio |
|-------------------------------------------|-------|-------|---------|-------|---------------------------------|
| Take back group                           | 0     | 4     | 1       | 1     | -                              |
| Fitzpatrick score                         | 0     | 5     | 1       | 1     | -                              |
| Race                                      | 0     | 4     | 1       | 1     | -                              |
| Hypertension                              | -40.283 | 11293.688 | 0       | 1     | 0.997 4.74E + 32               |
| Diabetes                                  | 75.239 | 56494.762 | 0       | 1     | 0.999                           |
| Autoimmune                                | -13.931 | 54740.615 | 0       | 1     | 0.999                           |
| History of DVT/PE                         | -56.965 | 96785.316 | 0       | 1     | 0.999   1.73E + 85            |
| History of miscarriage                    | 196.269 | 52578.12 | 0       | 1     | 0.999 1.29E + 85             |
| Family history of hypercoagulability      | -65.682 | 40036.098 | 0       | 1     | 0.999                           |
| Smoking status                            | -23.945 | 25569.834 | 0       | 1     | 0.999                           |
| Neoadjuvant chemotherapy                  | 21.575 | 16832.102 | 0       | 1     | 0.999 234542594               |
| Adjuvant chemotherapy                     | 7.86 | 17740.698 | 0       | 1     | 0.999 2591.354               |
| Neoadjuvant hormonal therapy              | 40.305 | 249165.449 | 0       | 1     | 5.19E + 17                    |
| Adjuvant hormonal therapy                 | -28.577 | 15604.582 | 0       | 1     | 0.999                           |
| Age at flap procedure                     | 1.237 | 1144.548 | 0       | 1     | 0.999 3.445                   |
| BMI for flap procedure                    | 1.801 | 1819.156 | 0       | 1     | 0.999 6.055                   |
| Preoperative VTE chemoprophylaxis duration| 81.36 | 35152.299 | 0       | 1     | 0.998 2.16E + 35             |
| Postoperative VTE chemoprophylaxis        | 0     | 3     | 1       | 1     | -                              |
| Flap type group                           | -199.703 | 78715.465 | 0       | 1     | 0.998                           |

Results of the binomial linear regression are summarized in this table. The covariates used in the regression were comprised of variables that included flap type, demographics, patient medical history, family history, cancer treatment, and venous thromboembolism prophylaxis.

Variable(s) entered on step 1: race, hypertension, diabetes, autoimmune, history of DVT/PE, history of miscarriage, family history of hypercoagulability, smoking status, age at flap procedure, BMI for flap procedure, neoadjuvant chemotherapy, adjuvant chemotherapy, neoadjuvant hormonal therapy, adjuvant hormonal therapy, neoadjuvant chemotherapy, postoperative VTE chemoprophylaxis duration, take back timing, flap type group, and Fitzpatrick score.

B, regression coefficient; CI, confidence interval; df, degree of freedom; SE, standard error; VTE, venous thromboembolism.
the vein or artery. Other options, specifically for venous congestion, that may be used but are less effective if primary measures fail include leeches, venocutaneous catheterization, and hyperbaric oxygen therapy.\(^3\)

Although this study has been able to highlight a very important topic, it does have certain limitations. One limitation of this article is that all vascular compromise was grouped together. It was difficult to obtain enough patients to score into each Fitzpatrick score skin tone without the addition of all vascular compromise rather than venous congestion alone. Another potential limitation was the exclusion of buried flaps and small skin paddles. Although this would have provided a minimal increase in the number of patients for the study population, these types of insets are not the same as larger skin patches. Buried flaps have no visible skin and, thus, are not relevant to outcomes based on Fitzpatrick skin tone. It was elected to remove the small skin paddles, as they can easily become bruised, and this creates difficulty with monitoring capillary refill. These insets also typically have an implantable Doppler, which could further skew the data. These limitations also resulted in a small cohort size that may have insufficiently powered the present study, but nevertheless, the findings are important enough to report on.

Future directions of this article include a more robust study that distinctly looks solely at venous congestion as the culprit of flap compromise. Venous congestion is typically the complication of major concern in the postoperative setting. One other aspect of this study is to see if increased monitoring measures listed in this article have any effect on the rates of flap loss in patients, particularly those with darker Fitzpatrick skin tones. Another possible future direction is looking into measures of case difficulty (ischemia time, number of anastomoses performed at index operation, and prior radiation), time measurements (flap compromise identified by nurse to evaluation by resident and evaluation by resident to getting into the operating room), and interventions at take back (number of anastomotic revisions, foggary, and tissue plasminogen activator). Considering that buried flaps and small patch skin closures were excluded in the present study, addressing these types of flaps in future studies may provide further insight to flap compromise in patients of darker skin tones. Finally, there is the potential use of the LACE+ index, a metric that can predict 30-day readmission after hospital discharge. The LACE+ index is an extension of the LACE index, which takes into account patient variables, such as length of stay, acuity of admission, comorbidity of patient, emergency department utilization.

Fig. 3. Example clinical photographs for each Fitzpatrick score skin type. Utilizing the Fitzpatrick scale in Table 1, examples of each Fitzpatrick score skin type of our patient population are noted in this figure. A, Example of Fitzpatrick score skin type I. B, Example of Fitzpatrick score skin type II. C, Example of Fitzpatrick skin type III. D, Example of Fitzpatrick skin type IV. E, Example of Fitzpatrick skin type V. F, Example of Fitzpatrick skin type VI.
within the past 6 months, age, and sex. A recent study has shown that the LACE+ index was a suitable predictive model for patients who underwent reconstructive procedures and, thus, may be utilized in patient populations such as the ones presented in this study.32

**CONCLUSIONS**

Minority patients face a disproportionate number of disparities in health care. The present study was able to highlight one of these disparities, showing that patients with darker Fitzpatrick skin tones were associated with higher rates of flap loss after vascular compromise. To prevent flap loss in these patients, more aggressive flap monitoring should be taken into consideration in the immediate postoperative setting.

**REFERENCES**

1. Misere RM, van Kuijk SM, Claassen EL, et al. Breast-related and body-related quality of life following autologous breast reconstruction is superior to implant-based breast reconstruction—a long-term follow-up study. *Br J Plast Surg*. 2021;74(4):175–182.

2. Sawyer JD, Franke J, Scaife S, et al. Autologous breast reconstruction is associated with lower 90-day readmission rates. *Plast Reconstr Surg Glob Open*. 2022;10:e4112.

3. Panchal H, Matros E. Current trends in postmastectomy breast reconstruction. *Plast Reconstr Surg*. 2017;140(5S Advances in Breast Reconstruction):7S–13S.

4. Epstein S, Tran BN, Cohen JB, et al. Racial disparities in postmastectomy breast reconstruction: national trends in utilization from 2005 to 2014. *Cancer*. 2018;124:2774–2784.

5. Offodiile AC II, Tsi TC, Wenger JB, et al. Racial disparities in the type of postmastectomy reconstruction chosen. *J Surg Res*. 2015;195:368–376.

6. Albornoz CR, Bach PB, Pusic AL, et al. The influence of socioeconomic factors and hospital characteristics on the method of breast reconstruction, including microsurgery: a U.S. population-based study. *Plast Reconstr Surg*. 2012;129:1071–1079.

7. Rubin LR, Chavez J, Alderman A, et al. ‘Use what God has given me’: difference and disparity in breast reconstruction. *Psychol Health*. 2013;28:1099–1120.

8. Bennett KG, Qj J, Kim HM, et al. Comparison of 2-year complication rates among common techniques for postmastectomy breast reconstruction. *JAMA Surg*. 2018;153:901–908.

9. Wong AK, Joanna Nguyen T, Peric M, et al. Analysis of risk factors associated with microvascular free flap failure using a multi-institutional database. *Microsurgery*. 2015;35:6–12.

10. Bui DT, Cordeiro PG, Hu QY, et al. Free flap reexploration: indications, treatment, and outcomes in 1193 free flaps. *Plast Reconstr Surg*. 2007;119:2092–2100.

11. Chen KT, Mardini S, Chuang DC, et al. Timing of presentation of the first signs of vascular compromise dictates the salvage outcome of free flap transfers. *Plast Reconstr Surg*. 2007;120:187–195.

12. Stranix JT, Lee ZH, Jacoby A, et al. Forty years of lower extremity take-backs: flap type influences salvage outcomes. *Plast Reconstr Surg*. 2018;141:1282–1287.

13. Fitzpatrick TB. The validity and practicality of sun-reactive skin types I through VI. *Arch Dermatol*. 1988;124:860–871.

14. Nelson Z, O’Neill L, Fisher AH, et al. Postoperative detection of free flap congestion in a Fitzpatrick skin type VI patient using the flir thermal imaging camera: a case report and literature review. *Plast Reconstr Surg Glob Open*. 2021;9(10S):127–128.

15. Ponticorvo A, Taday E, Mazhar A, et al. Evaluating visual perception for assessing reconstructed flap health. *J Surg Res*. 2015;197:210–217.

16. Roberts WE. Skin type classification systems old and new. *Dermatol Clin*. 2009;27:529–535, vii.

17. Armitage P. Tests for linear trends in proportions and frequencies. *Biometrics*. 1955;11:375–386.

18. Cochran WG. Some methods for strengthening the common χ² tests. *Biometrics*. 1954;10:417–451.

19. Harris PA, Taylor PR, Minor BL, et al; REDCap Consortium. The REDCap consortium: building an international community of software platform partners. *J Biomed Inform*. 2019;95:103208.

20. Harris PA, Taylor R, Thielke R, et al. Research electronic data capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform*. 2009;42:377–381.

21. IBM Corp. IBM SPSS Statistics for Mac, Version 28.0. Released 2021. Armonk, NY: IBM Corp.

22. Box GEP, Tidwell PW. Transformation of the independent variables. *Technometrics*. 1962;4:551–560.

23. Tabachnick BG, Fidell LS. Chapter 10: Logistic Regression. In: *Using Multivariate Statistics*. New York, NY: Pearson; 2013.

24. Las DE, de Jong T, Zuidam JM, et al. Identification of independent risk factors for flap failure: a retrospective analysis of 1530 free flaps for breast, head and neck and extremity reconstruction. *J Plast Reconstr Aesthet Surg*. 2016;69:894–906.

25. Lese I, Biedermann R, Constantinescu M, et al. Predicting risk factors that lead to free flap failure and vascular compromise: a single unit experience with 565 free tissue transfers. *J Plast Reconstr Aesthet Surg*. 2021;74:512–522.

26. Swartz WM, Izquierdo R, Miller MJ. Implantable venous Doppler microvascular monitoring: laboratory investigation and clinical results. *Plast Reconstr Surg*. 1994;93:152–163.

27. Rubins U, Marcinkevics Z, Cimurs J, et al. Multimodal device for real-time monitoring of skin oxygen saturation and microcirculation function. * Biosensors* (Basel). 2019;9:E97.

28. Jakubietz RG, Schmidt K, Bernuth S, et al. Evaluation of the intraoperative blood flow of pedicled perforator flaps using indocyanine green-fluorescence angiography. *J Plast Reconstr Advanc Surg*. 2020;146:296e–305e.