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# Split thickness skin graft meshing ratio indications and common practices

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ABSTRACT

*Background:* Split thickness skin grafting is a commonly used technique in burn surgery for resurfacing wounds that are unlikely to heal without scarring. Meshing and expanding skin grafts allow for reconstruction of larger wounds with smaller donor sites.
*Methods:* A retrospective chart review was performed of 210 patients with burns equal to or greater than 20% total body surface area admitted to Vancouver General Hospital between 1998 and 2014. Charts were reviewed to collect data on patient and burn demographics. A survey was sent to Canadian plastic surgeons registered with the CSPS to collect data on common practices in burn surgery nationwide.
*Results:* The patients that received 3:1 or higher meshed grafts were all flame burns, had a significantly higher average TBSA (51.89%±14.87 vs 29.13%±9.48, p=0.001), and a significantly higher full thickness burn TBSA (25.76%±21.97 vs 6.20%±9.04, p=0.001). We found no significant differences in gender, age, or burn location between the less than 2:1 and 3:1 or greater meshing ratio groups. The survey of plastic surgeons performing burn surgery in Canada revealed that 60% of responders had experience with skin grafts using meshing ratios of 3:1 or higher. Of these surgeons, 100% felt that burn size and 36% felt that burn location would influence their decision to use a 3:1 or higher meshing ratio.
*Conclusions:* A larger burn size is the major influencing factor for the use of higher skin graft meshing ratios by Canadian burn surgeons. Furthermore, burn location determines the choice of donor and recipient sites in these cases.


## 1. Introduction

Skin transplantation has a fascinating history and evolution from a humble beginning roughly 3000 years ago in India [1–3]. In this modern age, technological advances have popularized skin graft use for resurfacing of traumatic or chronic wounds by many medical specialties [4–6]. However, a pitfall of skin grafts is the creation of a secondary wound of identical size in the form of a donor site. Although this donor site is harvested as a split-thickness skin graft and therefore heals with less scarring, it does not eliminate scarring entirely [4–10]. In 1958, the first method for skin graft expansion was developed by Meek in the form of small postage stamp sized islands of graft spread over the recipient site [11]. In 1964, the Meek method was discontinued in favor of the new meshing technique invented by Tanner et al. [12]. To this day, surgeons use specialized meshing devices to expand harvested skin grafts to available ratios of 1:1, 1.5:1, 2:1, 3:1, 4:1, 6:1 and rarely to the maximum possible ratio of 9:1 [13,14]. Skin graft expansion

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allows for smaller donor sites per recipient area grafted. This in turn allows for immediate grafting of larger surface area wounds such as severe burns where limited donor areas are available. In addition to this primary benefit, skin graft meshing also reduces skin graft failure due to hematoma or seroma formation. However, disadvantages of meshing include an increased risk of failure due to shear forces and a less favorable cosmetic outcome (Fig. 1) [4–9].

Many studies have been published with creative approaches toward improving higher skin graft meshing ratios in order to maximize the benefits and reduce the risks associated with these grafts [15–23]. However, with the rapid global acceptance of the skin graft meshing technique, there have been no studies reporting specific indications for the use of a certain ratio over another. This decision is left to the surgeon based on their individual experience and comfort with meshed grafts.

We present a retrospective chart review of 210 patients with burns greater than or equal to 20% TBSA to identify common indications for the use of 3:1 or higher meshing ratio. Additionally, a questionnaire was sent out to Canadian plastic surgeons to identify common meshing ratio practices across the country.

## 2. Methods

### 2.1. *Retrospective chart review*

The Vancouver General Hospital burn database was accessed to identify patients that were admitted with burns greater than or equal to 20% TBSA between 1998 and 2014. All charts were reviewed by a single reviewer. Data collected included patient age, gender, and burn details such as etiology, size,

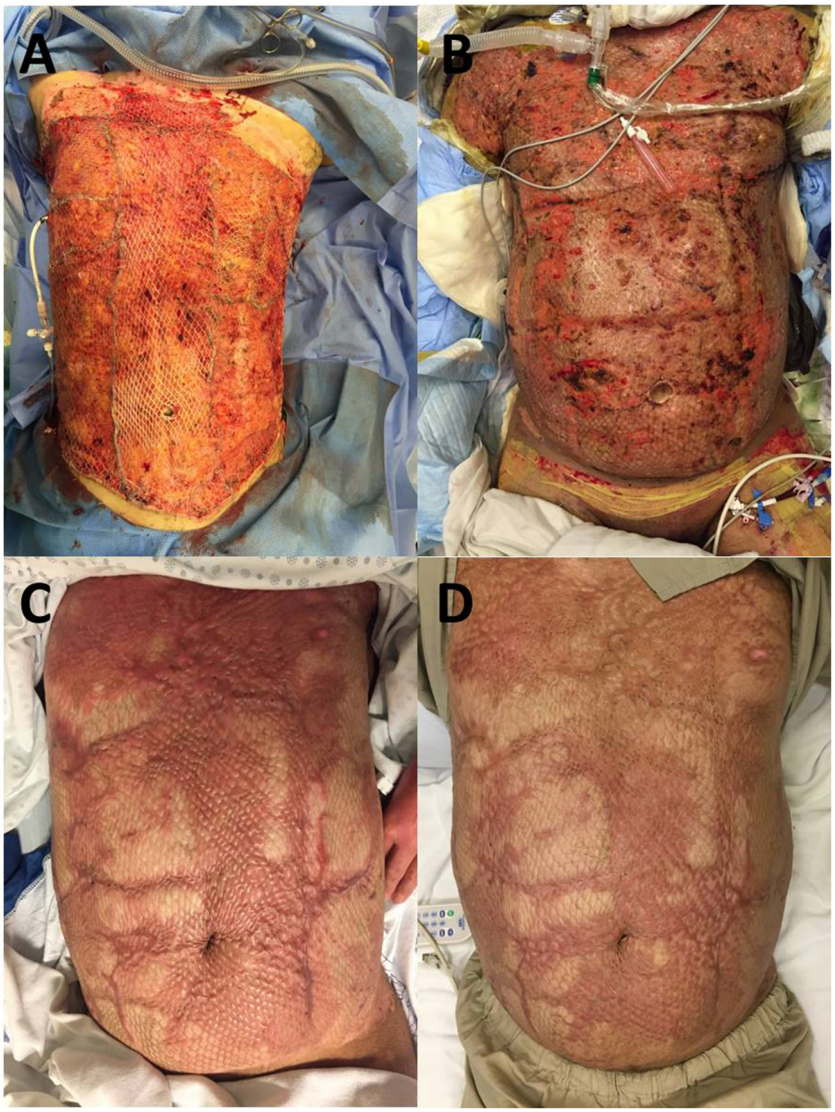


**Fig. 1 – A 34 year old male with 60% TBSA flame burn treated with 3:1 meshed split thickness skin graft and healing over time at (A) immediately post operatively, (B) 2 weeks, (C) 5 months, and (D) 1 year.**

location, and depth. Operative reports were reviewed to identify patients that received skin grafts with meshing ratios of 3:1 or higher. The operative reports of patients that received 3:1 or higher meshed grafts were reviewed more closely for details of graft donor site, recipient site, and dressings used.

### 2.2. Burn surgery survey

A questionnaire was sent to all surgeons registered with the Canadian Society of Plastic Surgery (CSPS) to survey their experience with meshed skin grafts. Questions were designed to determine how frequently the surgeons performed burn surgery, how often 3:1 or higher meshing ratios were used, and what burn characteristics surgeons used to influence their decision to use higher meshing ratios.

### 2.3. Statistical analysis

SPSS v20.0 software was used for statistical analysis of data. An independent t-test was used to compare means between <2:1 and 3:1 meshing groups.

## 3. Results

### 3.1. Chart review

The burn database query identified 210 patients admitted between 1998 and 2014 with burns equal to or greater than 20% TBSA. Of these, 157 were male and 53 were female with an average age of 41 years and average TBSA of 34.30%. Further chart review determined that of the 210 patients, 158 were treated with split thickness skin grafts (STSG) meshed at a ratio of 1.5:1, 4 were treated with a STSG meshed at a ratio of 2:1, and 48 were treated with STSG meshed at a ratio of 3:1 or higher (Table 1).

When compared to the <2:1 meshing ratio group, the patients that received 3:1 or higher meshed grafts were all flame burns, had a significantly higher average TBSA (51.89% ±14.87 vs 29.13%±9.48, p=0.001), and a significantly higher full thickness burn TBSA (25.76%±21.97 vs 6.20%±9.04, p=0.001). There were no significant differences in gender, age, or burn location between the <2:1 and 3:1 meshing ratio groups (Table 1).

Review of all burn operation reports identified a total of 104 operations involving 3:1 or higher meshing ratios in the 48 patients treated with 3:1 or higher ratio meshed skin grafts. In the 104 surgical reports, there were 141 recipient sites and 152 donor sites listed. The head/neck area was more likely to be used as a donor (scalp in all cases) than a recipient site (N=13 vs 2). Contrarily, the upper extremity was more likely to be used as a recipient than a donor site (N=37 vs 14). There were no significant differences in likelihood of the trunk or lower extremity to serve as donor or recipient sites (Table 2).

Prior to 2007, all cases of 3:1 mesh ratio skin grafts were dressed with 1.5:1 meshed cadaver allograft, and all cases later than 2007 were dressed with Jelonet©.

**Table 1 – Patient demographics of 210 total burns with greater than 20% TBSA presenting to VGH between 1998 and 2014.**

| | STSG mesh ratio | | | |
|---|---|---|---|---|
| | 1.5:1 | 2:1 | 3:1 | Total |
| Total patients | 158 | 4 | 48 | 210 |
| Gender | | | | |
| Male | 118 | 2 | 37 | 157 |
| Female | 40 | 2 | 11 | 53 |
| Age | | | | |
| Min | 8 | 31 | 14 | 8 |
| Max | 89 | 80 | 72 | 89 |
| Average | 41.6 | 50.75 | 39.23 | 41.23 |
| Etiology | | | | |
| Flame | 119 | 3 | 49 | 171 |
| Scald | 26 | 1 | 0 | 27 |
| Electrical | 11 | 0 | 0 | 11 |
| Chemical | 2 | 0 | 0 | 2 |
| TBSA | | | | |
| Min | 20 | 20 | 24 | 20 |
| Max | 65 | 32 | 87 | 87 |
| Average | 29.13 | 27.13 | 51.89 | 34.3 |
| Location (TBSA) | | | | |
| Head/neck | 1.89 | 3.25 | 4.04 | 2.4 |
| Trunk | 9.56 | 13.38 | 15.15 | 10.91 |
| Upper extremity | 7.61 | 8.63 | 11.45 | 8.51 |
| Lower extremity | 9.8 | 1.5 | 20.34 | 12.07 |
| Depth (TBSA) | | | | |
| Partial thickness | 22.55 | 20.75 | 25.01 | 23.08 |
| Full thickness | 6.2 | 6 | 25.76 | 10.66 |

### 3.2. Burn surgery survey

The questionnaire was sent to 414 plastic surgeons registered with the CSPS. There were 45 responses with a response rate of 11%. The responders had a mixed level of experience with regards to length of time practicing burn surgery and number of operations done per year (Fig. 2).

**Table 2 – Donor and recipient sites of 3:1 meshed STSG during 104 surgeries on 48 patients between 1998 and 2014.**

| Location | Number of recipient sites (N) | Number of donor sites (N) |
|---|---|---|
| Head/neck | 2 | 13 |
| Chest | 16 | 12 |
| Abdomen | 12 | 27 |
| Back | 25 | 28 |
| Buttock | 10 | 9 |
| Shoulder | 8 | 3 |
| Arm/forearm | 29 | 11 |
| Thigh | 9 | 15 |
| Leg | 30 | 29 |
| Feet | 0 | 5 |
| Total | 141 | 152 |

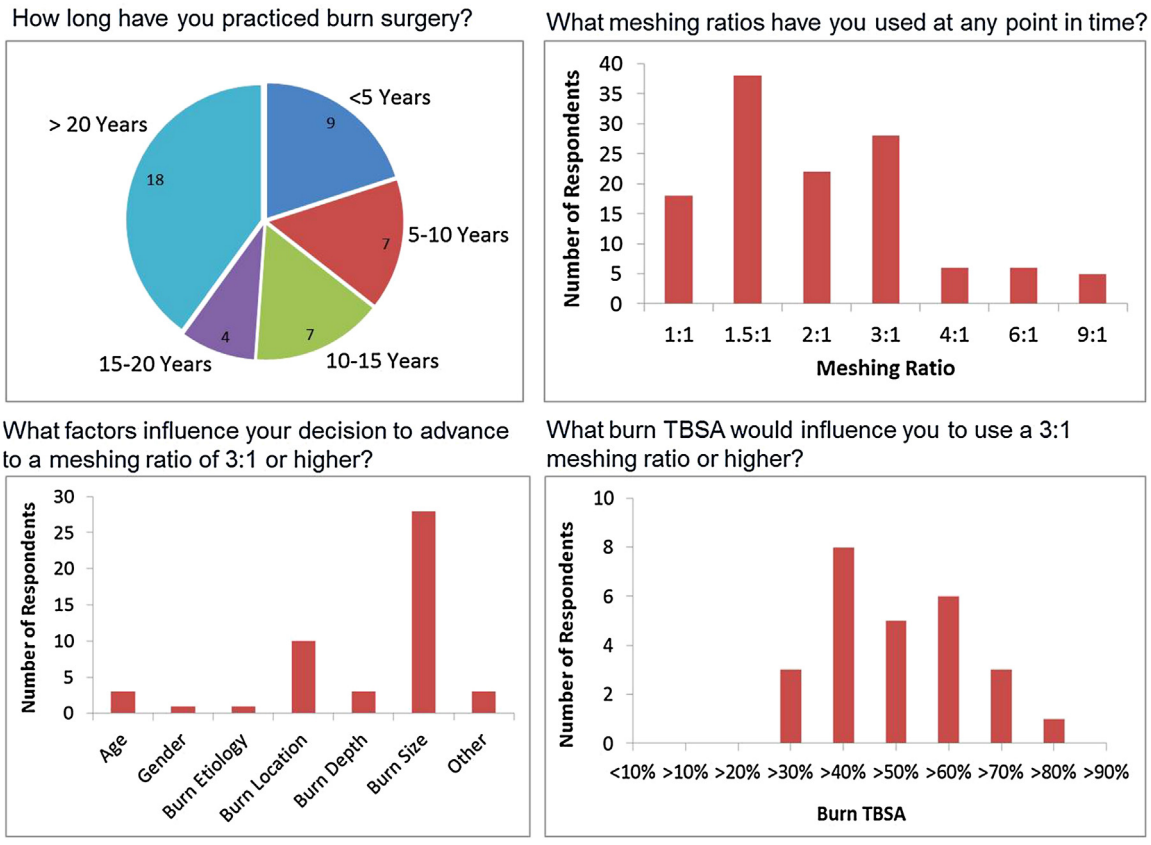


**Fig. 2 – Series of questions included in national burn surgeon survey.**

Results showed that 62% of responders had experience with skin grafts using meshing ratios up to 3:1, but only 13% had experience with meshing ratios of 4:1 or 6:1, and only 11% had experience with meshing ratios up to a maximum of 9:1 (Fig. 2).

Of those surgeons with experience using meshing ratios of 3:1 or higher, 100% felt that burn size would influence their decision to use a 3:1 or higher meshing ratio. When asked what the lowest burn size would have to be to consider using a 3:1 or higher meshing ratio answers varied from 30 to 80% with a majority 29% of respondents reporting a minimum TBSA greater than 40%. Additionally 36% of surgeons with 3:1 meshing ratio experience felt that burn location played a role in the decision to advance to a higher meshing ratio. The chest, back and thigh were the most preferred locations for 3:1 meshed grafts. Only 4–12% believed that age, gender, etiology or depth played a role in the decision (Fig. 2).

Most common dressings used frequently by responders to cover 3:1 meshed skin grafts were Jelonet© (64%), Acticoat© (50%), and allograft in a sandwich technique (50%).

## 4. Discussion

Split thickness skin grafting is a common technique employed by burn surgeons to resurface wounds that are predicted to heal poorly based on their depth. Meshing and expanding skin grafts allow for coverage of larger areas while minimizing the donor site defect [4–7]. Correct use of meshing and expansion ratios is crucial for large burns where limited donor sites are available. Selecting the appropriate expansion ratio allows surgeons to cover all burnt areas within a shorter time frame thereby reducing the complications of prolonged open wounds. Although these techniques are employed by burn surgeons globally, there is limited literature to describe the indications or guidelines for skin graft meshing and expansion ratios. We present a retrospective chart review and national survey to outline current practices at our large burn center and at burn centers across Canada respectively.

### 4.1. *Burn patient demographics*

At our center, a trauma and burn database is maintained for quality control and research purposes. A search of this database for patients admitted with 20% or higher burn TBSA between 1998 and 2014 identified 210 patients for review. There was a higher number of males (157) than females (53) identified suggesting that males have a higher predisposition to suffering a significant burn in their lifetime. This is consistent with previous literature studying burn epidemiology [24,25]. The patients identified ranged from 8 to 89 years of age with an average age of 41. Although most pediatric burns are treated at the BC Children's Hospital, occasional pediatric

patients were treated at Vancouver General Hospital and 9 patients under the age of 18 were included in the chart review. Although age is known to affect healing potential, we did not feel it was necessary to exclude these younger patients as outliers. Burn etiologies included flame burns (171), followed by scald (27), and fewer electrical (11) or chemical burns (2). As expected, the most common way to suffer a significant burn is as a result of a fire which is consistent with prior literature in burn epidemiology [24,25]. Burn sizes ranged from 20% TBSA (minimum inclusion criteria) up to a maximum 87% TBSA (Table 1). Numerous other factors such as socioeconomic status, geography, social and personal tendencies play a role in burn etiology, size and location which are out of this paper's scope [26–31].

### 4.2. STSG meshing and expansion ratio comparison groups

Once all patients that met the inclusion criteria were identified, all chart operative reports were reviewed to separate all patients into three groups based on the highest STSG meshing ratio used. Patients were grouped into 1.5:1, 2:1, and 3:1 or higher meshing ratio groups. Only 4 patients received 2:1 meshed STSG during their admission suggesting that this is an uncommonly used ratio at our burn center. These 4 patients are included in the reported tables but were not further statistically analyzed due to poor statistical power. Although the availability of specific meshing ratio devices at certain centers may limit a surgeon's choice to the ratios that are available at their institution, the general approach to using a larger (3:1–9:1) instead of a traditional 1.5:1 or 2:1 meshing ratio remains the same and can be based on the guidelines that follow. The remaining 1.5:1 (referred to as the <2:1 group from here on out) and 3:1 groups were then compared to identify variables that may serve as indications for higher meshing ratio use (Table 1).

### 4.3. Burn TBSA and depth

The major difference between <2:1 and 3:1 meshed STSG patient groups was the burn size. The TBSA burned in the <2:1 patient group ranged from 20% to 65% with an average TBSA of 29%. The 3:1 patient group had TBSA burns ranging from 24% to 87% with an average TBSA of 52%. Essentially, patients in the 3:1 meshing ratio group had 1.79 times larger burns than those in the <2:1 meshing group. Only 11 patients had burn TBSAs of under 40% with the other 38 patients having burn TBSAs greater than 40%. It is important to note that since smaller burns of less than 20% TBSA were excluded from this chart review, the true difference between <2:1and 3:1 meshing groups is even more pronounced than reported here. This suggests that although a 3:1 meshing ratio can be used for smaller burns, it was much more likely to be used in patients with burn TBSAs equal to or greater than 40%. Even though better skin coverage is achieved with the larger expansion ratio, the less optimal esthetic outcome makes smaller expansion rations more preferable.

Furthermore, patients in the 3:1 meshing group had a larger full thickness burn. TBSA of full thickness burn in the <2:1 patient group ranged from 0 to 46% with an average of 6%. The 3:1 patient group had a higher component of full thickness TBSA with a range of 0–65% and an average of 26%. This suggests that although a full thickness burn is not required to use a 3:1 or higher meshing ratio, surgeons were more likely to decide to use a higher meshing ratio when there was a larger full thickness component. However, this relationship may be indirectly based on larger overall burns having more full thickness involvement (Table 1).

### 4.4. Burn etiology

Although all the 3:1 ratio patients had flame related burns, it is difficult to draw a conclusion on this relationship given the fact that scald, electrical and chemical burns occur at a lower frequency and this study was not powered enough to capture these less common burn etiologies. However, it is possible that flame based burns were more likely to result in the higher TBSAs that then required 3:1 or higher meshing ratios. In this sense, flame burns are indirectly more likely to receive 3:1 or higher meshed skin grafts (Table 1).

### 4.5. Burn location

Patients in the 3:1 meshing ratio group compared to the <2:1 group had larger TBSA burns in each anatomical area. Similarly to the previously noted 1.79 time increase in overall TBSA between the 3:1 and <2:1 groups, the increase in TBSA per anatomic location was 2.14 in the head and neck, 1.57 in the trunk, 1.5 in the upper extremity, and 2.07 in the lower extremity. It appears that the 3:1 meshing ratio patients had relatively larger burns in the head and neck, and lower extremity whereas their trunk and upper extremity burns did not increase in size as dramatically. The variable increase in burn size per anatomic location is likely secondary to burn mechanism. If burns occur more frequently in the upper extremity and trunk where the individual is interacting with a fire source using their hands, as the burn severity increases, more of the individual's head and neck and lower extremity is involved (Table 1).

### 4.6. Age and gender

There was no difference in age in gender between 3:1 and <2:1 meshing ratio patient groups suggesting that these variables play no role in the decision to use a higher meshing ratio (Table 1).

### 4.7. 3:1 meshed STSG donor and recipient sites

The operative reports that described a 3:1 meshed STSG were closely reviewed for all donor and recipient sites selected for the skin grafting procedure. The 48 patients that underwent skin grafting with 3:1 meshed grafts or higher had a total of 104 surgeries using higher ratio grafts. Although these 48 patients also received <2:1 meshed skin grafts throughout their admission, only the 3:1 meshed surgeries were recorded. In the 104 surgical reports using 3:1 meshed grafts, there were 152 donor sites and 141 recipient sites listed.

The head and neck was more likely to be used as a donor site (13) than a recipient site (2). In all 13 cases where the head and neck was used as a donor site, the skin graft was harvested

from the scalp. This likely represents burns where limited donor sites are available and use of the scalp is then required. Conversely, the upper extremity was more likely to be used as a recipient site (37) than a donor site (14), which is likely primarily due to the higher percentage of upper extremity involvement in large burns resulting in limited donor sites in this anatomic area. The use of the trunk and lower extremity as donor sites was not significantly higher than their use as recipient sites (Table 2).

### 4.8. *National burn surgery survey*

A questionnaire was sent to 414 surgeons registered with the Canadian Society of Plastic Surgery. There were 45 responses with a survey response rate of 11%. Although this is a rather small response rate, not all surgeons registered with the CSPS perform burn surgery in their practice and therefore were not expected to contribute to the survey. The first invitation to participate was sent to all 414 CSPS members which led to 42 responses. A second invitation was sent to a smaller group of surgeons identified as high volume burn surgeons which generated 3 more responses. Responses were received from British Columbia, Ontario, Quebec, Saskatchewan, New Brunswick and Nova Scotia.

All 28 respondents with experience using 3:1 meshing ratios reported that burn size would impact their decision to use a 3:1 or higher meshing ratio, and 10 respondents reported that burn location played a role in the decision. The minimum burn TBSA required before surgeons would consider using a higher 3:1 meshing ratio varied from 30 to 80% but no respondents believed in using a higher meshing ratio in burns smaller than 30% TBSA. Those respondents that believed burn location played a role in their decision to use a higher meshing ratio preferred the back and thigh (90%), chest (70%), arm (60%), leg (50%), and forearm (30%) as burn locations for grafting. None supported the head and neck, or hands as appropriate locations (Fig. 2).

### 4.9. *Future considerations*

Now that a clear indication for the use of higher meshing ratio skin grafts has been established, further chart review into patient outcomes, aesthetics, complications, number of surgeries, and length of admission in <2:1 vs 3:1 mesh ratio patient groups could serve as additional support for the use of certain meshing ratios over others.

## 5. Conclusion

According to a local retrospective chart review and national burn surgeon questionnaire, burn size in TBSA is the only consistent factor considered in the decision to use a 3:1 or higher split thickness skin graft meshing ratio. When treating a large burn, a 3:1 or higher meshing ratio should be considered once the burn TBSA approaches 30-50% or higher. Flame etiology and full thickness burn depth were indirectly more likely to be associated with higher TBSA and therefore with more 3:1 meshed skin graft use. Once the decision to use 3:1 ratio is made, certain locations are preferentially used as donors/recipients based on availability of skin and cosmetic considerations.

## Disclosure

None of the authors has a financial interest in any of the products, devices, or drugs mentioned in this manuscript.

## Conflict of interest

The authors declare that they have no conflict of interest.

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