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COMPARISON OF TUMESCENT AND NON-TUMESCENT TECHNIQUES IN SPLIT-THICKNESS SKIN GRAFT HARVESTING: AN OBSERVATIONAL COMPARATIVE STUDY OF 90 CASES

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ABSTRACT

Background: Split-thickness skin grafting (STSG) is a cornerstone reconstructive procedure. The tumescent technique—subdermal infiltration of a dilute lidocaine–adrenaline solution—may reduce intra-operative blood loss and improve graft outcomes, but comparative evidence, particularly in the Indian population, is limited.
Objective: To compare early graft uptake, donor site healing, and short-term outcomes between tumescent and non-tumescent STSG harvesting.
Methods: In this observational comparative study, 90 patients requiring STSG were grouped according to the technique received—Group A (tumescent, n = 45) or Group B (non-tumescent, n = 45). A blinded assessor measured graft uptake on day 5, donor site healing on day 10, and final healing at 3 weeks by planimetry of standardized photographs. Continuous variables were compared by independent-samples t-test and categorical variables by chi-square or Fisher's exact test ($p < 0.05$ significant).
Results: Mean graft uptake on day 5 was significantly higher in the tumescent group (96.2 ± 4.8% vs. 92.1 ± 5.2%; $p < 0.001$), as was donor site healing on day 10 (98.4 ± 2.6% vs. 95.3 ± 3.1%; $p < 0.001$). At 3 weeks, outcomes were comparable (97.8 ± 2.4% vs. 97.1 ± 2.6%; $p = 0.19$).
Conclusion: The tumescent technique offers superior early graft uptake and donor site healing, while final outcomes at 3 weeks are comparable. Both techniques are safe and effective.

KEYWORDS: split-thickness skin graft; tumescent technique; graft uptake; donor site healing; adrenaline; lidocaine

INTRODUCTION

Split-thickness skin grafting (STSG) is among the most commonly performed reconstructive procedures for traumatic wounds, burns, chronic ulcers, and post-debridement defects [1]. With origins tracing back to ancient India [2], graft success depends primarily on recipient-bed vascularity and the graft's early revascularisation through plasmatic imbibition, inosculation, and angiogenesis [3].

STSG remains associated with intra-operative blood loss, postoperative pain, and donor site morbidity, and traditional haemostatic methods—tourniquet, electrocautery, and adrenaline-soaked gauze—may not adequately control bleeding [4,5]; excessive blood loss impairs graft adherence and promotes haematoma formation [6]. The tumescent technique, developed by Klein for liposuction [7], involves subdermal infiltration of a dilute solution of lidocaine, adrenaline, and sodium bicarbonate: adrenaline reduces intra-operative blood loss [8], while lidocaine provides analgesia and has bacteriostatic properties [9]. Reduced blood loss with this approach has been demonstrated in burn surgery [10–12]. Rajendran and Koujalagi et al. reported improved graft take and donor site healing with the tumescent technique [13,14], although concerns persist regarding prolonged vasoconstriction [15]; Blome-Eberwein et al. found its vasoconstrictive effect transient and without adverse effect on healing [16]. As wound healing proceeds through haemostasis, inflammation, proliferation, and remodelling and is influenced by age, diabetes, nutrition, and local blood supply [17,18], outcomes may differ across patient groups. Given the limited comparative evidence, particularly in the Indian population, this study compared tumescent and non-tumescent STSG harvesting at a tertiary care centre.

MATERIALS AND METHODS

Study Design and Setting

This observational, two-arm comparative study was conducted in the Department of General Surgery, Sree Balaji Medical College and Hospital, Chennai, over 18 months, in accordance with the Declaration of Helsinki.

Study Population and Sample Size

The sample size was calculated to detect a clinically meaningful difference in mean graft uptake, based on the ~2.5% difference reported by Rajendran [13]. Assuming an expected difference (δ) of 3%, a common standard deviation (σ) of

5%, a two-sided α of 0.05 ($Z_{1-\alpha/2} = 1.96$), and 80% power ($Z_{1-\beta} = 0.84$), the required sample size per group was estimated using the formula for comparison of two independent means:

$n = 2 \times (Z_{1-\alpha/2} + Z_{1-\beta})^2 \times \sigma^2 / \delta^2$

This yielded approximately 44 patients per group, rounded up to 45 per group (90 total) to allow for incomplete follow-up. Patients were grouped according to the technique received: Group A (tumescent) and Group B (non-tumescent).

Group Allocation and Blinding

As an observational study, no randomization or allocation concealment was undertaken. During the study period, patients undergoing STSG were managed with either the tumescent or non-tumescent technique according to the operating surgeon's preference and standard departmental practice, and were enrolled consecutively and grouped according to the technique received. To minimise detection bias, the outcome assessor who measured graft uptake and donor site healing, and the statistician who analysed the data, were blinded to group allocation.

Eligibility Criteria

Inclusion: Patients aged 18–65 years with clean wounds prepared for grafting, without major comorbidities (except diabetes mellitus), providing written informed consent.

Exclusion: Hypertension, liver disease, renal failure, malignancy, vasculitis, HIV/AIDS, protein-energy malnutrition, haemoglobin < 10 g/dL, serum albumin < 30 g/dL, adrenaline allergy, active wound infection (beta-haemolytic streptococcus, Citrobacter, or Acinetobacter), smoking within six months, and chemical or electrical burns.

Operative Technique

Group A (Tumescent): A modified tumescent solution (20 mL of 2% lidocaine [400 mg], 1 mL of 1:1000 adrenaline [1 mg], and 10 mL of 8.4% sodium bicarbonate in 500 mL normal saline; final concentrations ~0.075% lidocaine and 1:530,000 adrenaline) was infiltrated subdermally at the donor site until adequate tumescence was achieved [7]. After 10 minutes for vasoconstriction, the STSG was harvested using a dermatome or Humby's knife and applied to the recipient site.

Group B (Non-tumescent): STSG harvesting was performed without prior infiltration [1]; haemostasis was achieved with pressure and electrocautery. All patients received standard postoperative care.

Outcome Measures and Assessment

Primary outcomes were percentage graft uptake at the recipient site on day 5, percentage donor site healing on day 10, and final healing at 3 weeks. Graft uptake was defined as the proportion of the grafted area showing viable, vascularised adherence, and donor healing as the proportion showing complete re-epithelialisation; both were quantified by planimetry of standardized digital photographs (fixed distance and lighting) by an assessor blinded to allocation. Secondary analyses examined associations of age, gender, and wound aetiology with graft uptake.

Statistical Analysis

Data were analysed in IBM SPSS Statistics v22. Normality was assessed with the Shapiro–Wilk test. Normally distributed continuous variables were expressed as mean ± SD and compared using the independent-samples (unpaired) t-test; categorical variables, including the proportion achieving ≥95% uptake, were compared using the Pearson chi-square test, with Fisher's exact test where expected cell counts were < 5. A two-sided $p < 0.05$ was considered significant.

RESULTS

Participant Flow

Ninety patients were enrolled and grouped according to the technique received (45 per group). All completed assessments on day 5, day 10, and at 3 weeks, with no dropouts; all were included in the analysis.

Demographic and Baseline Characteristics

Most patients were aged 41–50 years (n = 34, 37.8%), followed by 51–65 years (n = 26, 28.8%), with a male predominance (n = 56, 62.2%). Baseline characteristics were comparable between groups ($p > 0.05$; Table 1), reducing potential confounding.

Table 1. Demographic characteristics (n = 90)

Variable	Group A (n = 45)	Group B (n = 45)	Total (n = 90)
Age (years)			
18–30	7 (15.6%)	8 (17.8%)	15 (16.7%)
31–40	6 (13.3%)	9 (20.0%)	15 (16.7%)
41–50	18 (40.0%)	16 (35.6%)	34 (37.8%)
51–65	14 (31.1%)	12 (26.6%)	26 (28.8%)
Gender			

Variable	Group A (n = 45)	Group B (n = 45)	Total (n = 90)
Male	29 (64.4%)	27 (60.0%)	56 (62.2%)
Female	16 (35.6%)	18 (40.0%)	34 (37.8%)

No significant difference between groups for age or gender (chi-square test, $p > 0.05$).

Indications and Donor Sites
Diabetic foot ulcer was the most common indication (n = 25, 27.8%), followed by traumatic ulcers (n = 20, 22.2%), burns (n = 14, 15.6%), chronic non-specific ulcers (n = 12, 13.3%), arterial ulcers (n = 11, 12.2%), and venous ulcers (n = 8, 8.9%); distributions were comparable between groups ($p > 0.05$; Table 2). The thigh was the most frequent donor site (n = 56, 62.2%), followed by the leg (16.7%), buttock (10.0%), upper arm (6.7%), and other sites (4.4%).

Table 2. Distribution by indication (n = 90)

Indication	Group A (n = 45)	Group B (n = 45)	Total (n = 90)
Diabetic foot ulcer	14 (31.1%)	11 (24.4%)	25 (27.8%)
Traumatic ulcer	10 (22.2%)	10 (22.2%)	20 (22.2%)
Burns	7 (15.6%)	7 (15.6%)	14 (15.6%)
Chronic non-specific ulcer	5 (11.1%)	7 (15.6%)	12 (13.3%)
Arterial ulcer	5 (11.1%)	6 (13.3%)	11 (12.2%)
Venous ulcer	4 (8.9%)	4 (8.9%)	8 (8.9%)

No significant difference in indications between groups (chi-square test, $p > 0.05$).

Graft Uptake on Postoperative Day 5
Mean graft uptake on day 5 was significantly higher in the tumescent group (96.2 ± 4.8%) than the non-tumescent group (92.1 ± 5.2%; unpaired t-test, $t = 3.89$, $p < 0.001$). A greater proportion achieved ≥95% uptake in Group A (77.8%) than Group B (57.8%; $\chi^2 = 4.12$, $p = 0.042$) (Table 3).

Table 3. Graft uptake at recipient site on postoperative day 5 (n = 90)

Graft uptake on day 5	Group A (n = 45)	Group B (n = 45)
≥95%	35 (77.8%)	26 (57.8%)
90–94%	8 (17.8%)	13 (28.9%)
<90%	2 (4.4%)	6 (13.3%)
Mean (± SD)	**96.2 ± 4.8**	**92.1 ± 5.2**

Mean values compared by unpaired t-test ($p < 0.001$); proportion achieving ≥95% by chi-square test ($p = 0.042$).

Donor Site Healing on Postoperative Day 10
Mean donor site healing on day 10 was significantly greater in the tumescent group (98.4 ± 2.6% vs. 95.3 ± 3.1%; $t = 5.14$, $p < 0.001$), with ≥95% healing in 84.4% vs. 64.4% ($\chi^2 = 4.73$, $p = 0.030$) (Table 4).

Table 4. Donor site healing on postoperative day 10 (n = 90)

Donor site healing, day 10	Group A (n = 45)	Group B (n = 45)
≥95%	38 (84.4%)	29 (64.4%)
90–94%	6 (13.3%)	11 (24.4%)
<90%	1 (2.2%)	5 (11.1%)
Mean (± SD)	**98.4 ± 2.6**	**95.3 ± 3.1**

Mean values compared by unpaired t-test ($p < 0.001$); proportion achieving ≥95% by chi-square test ($p = 0.030$).

Final Outcomes at 3 Weeks
At 3 weeks, 41 patients (91.1%) in Group A and 39 (86.7%) in Group B achieved complete healing, with none below 95%. Mean healing was comparable (97.8 ± 2.4% vs. 97.1 ± 2.6%; $t = 1.33$, $p = 0.19$) (Table 5).

Table 5. Healing at 3-week follow-up (n = 90)

Outcome at 3 weeks	Group A (n = 45)	Group B (n = 45)
Complete healing (100%)	41 (91.1%)	39 (86.7%)
Near-complete (95–99%)	4 (8.9%)	6 (13.3%)
Incomplete (<95%)	0 (0%)	0 (0%)
Mean (± SD)	**97.8 ± 2.4**	**97.1 ± 2.6**

Mean values compared by unpaired t-test (p = 0.19, not significant).

Association of Age, Gender, and Aetiology with Graft Uptake

On exploratory subgroup analysis, the highest proportion achieving ≥95% uptake was seen in patients aged 41–50 years (79.4%) and the lowest in those aged 51–65 years (53.8%); males fared better than females (75.0% vs. 55.9%), and burn wounds had the most favourable outcomes (92.9%) versus chronic non-specific ulcers (50.0%). None of these associations reached statistical significance (chi-square / Fisher's exact, p > 0.05), and they should be regarded as hypothesis-generating given the small subgroup sizes (Tables 6–8).

Table 6. Association between age and graft uptake on day 5 (n = 90)

Age (years)	≥95% uptake	90–94% uptake	<90% uptake	Total
18–30	10 (66.7%)	4 (26.7%)	1 (6.6%)	15
31–40	10 (66.7%)	4 (26.7%)	1 (6.6%)	15
41–50	27 (79.4%)	6 (17.6%)	1 (3.0%)	34
51–65	14 (53.8%)	7 (26.9%)	5 (19.3%)	26

Fisher's exact test, p > 0.05 (not significant).

Table 7. Association between gender and graft uptake on day 5 (n = 90)

Gender	≥95% uptake	90–94% uptake	<90% uptake	Total
Male	42 (75.0%)	11 (19.6%)	3 (5.4%)	56
Female	19 (55.9%)	10 (29.4%)	5 (14.7%)	34

Chi-square test, p > 0.05 (not significant).

Table 8. Association between wound aetiology and graft uptake on day 5 (n = 90)

Aetiology	≥95%	90–94%	<90%	Total
Diabetic foot ulcer	14 (56.0%)	8 (32.0%)	3 (12.0%)	25
Traumatic ulcer	15 (75.0%)	4 (20.0%)	1 (5.0%)	20
Burns	13 (92.9%)	1 (7.1%)	0 (0%)	14
Chronic non-specific	6 (50.0%)	4 (33.3%)	2 (16.7%)	12
Arterial ulcer	7 (63.6%)	3 (27.3%)	1 (9.1%)	11
Venous ulcer	6 (75.0%)	1 (12.5%)	1 (12.5%)	8

Fisher's exact test, p > 0.05 (not significant).

DISCUSSION

Demographic Profile, Indications, and Donor Sites

Most patients were middle-aged males, consistent with the distributions reported by Rajendran and Koujalagi et al. [13,14]; male predominance (62.2%) likely reflects greater occupational trauma and lifestyle-related ulcers [16], and the two groups were comparable at baseline (Table 1), reducing potential confounding. Diabetic foot ulcer was the leading indication, reflecting the high burden of diabetes in the Indian population and its known impairment of healing [19], and was similarly the commonest indication in Rajendran's series [13]. The thigh was preferred (62.2%) for its large surface area and favourable healing [2].

Graft Uptake on Day 5

Mean graft uptake was significantly higher in the tumescent group (96.2 ± 4.8% vs. 92.1 ± 5.2%; p < 0.001), consistent with Rajendran [13]. This likely reflects the vasoconstrictive action of adrenaline, which reduces bleeding and haematoma formation [8] and promotes close graft–bed contact during imbibition and inosculation [3]. Graft take is nonetheless multifactorial—intact healing cascades and systemic factors such as diabetes and nutrition matter [17,18]—and adrenaline infiltration, while safe, has not shown unequivocal superiority, with comparable uptake reported when meticulous haemostasis is ensured [6,16].

Donor Site Healing on Day 10

Donor site healing was significantly superior in the tumescent group (84.4% vs. 64.4% achieving ≥95% epithelialisation, $p = 0.030$; mean $p < 0.001$), in keeping with Koujalagi et al. [14]; reduced bleeding, less tissue trauma, and lower inflammation favour early healing [10,20]. Evidence is mixed, however: differences were not clinically significant at later follow-up for Rajendran [13], Blome-Eberwein et al. found no clear superiority despite preserved perfusion [16], and Demirtas et al. attributed donor healing mainly to graft thickness and patient factors rather than infiltration alone [21].

Outcomes at 3 Weeks

At 3 weeks, outcomes were comparable (97.8 ± 2.4% vs. 97.1 ± 2.6%; $p = 0.19$), consistent with Rajendran and Koujalagi et al. [13,14]. As long-term remodelling depends on gradual collagen reorganisation and vascular maturation rather than early interventions [22], the advantages of the tumescent technique appear confined to the early postoperative period.

Influence of Aetiology, Age, and Gender

On exploratory analysis, burn wounds showed the most favourable uptake and chronic/diabetic ulcers the least, consistent with impaired microcirculation in chronic wounds [19], while older patients (51–65 years) fared worse, in keeping with age-related decline in healing efficiency [18,23]. None of these subgroup associations reached statistical significance, however, and they should be regarded as hypothesis-generating rather than confirmatory.

LIMITATIONS

As an observational, non-randomized study, group assignment reflected clinical practice rather than random allocation, so the findings are subject to potential selection bias and residual confounding; although baseline characteristics were comparable between groups, unmeasured differences cannot be excluded. The sample, although powered for the primary comparison of mean graft uptake, was modest, and the subgroup analyses by age, gender, and aetiology were underpowered and should be interpreted cautiously. Potential confounders such as diabetes were not adjusted for in a multivariable model. The study was single-centre, limiting generalisability, and long-term endpoints (scar quality, pigmentation) and patient-reported outcomes (pain, satisfaction) were not formally assessed.

CONCLUSION

The tumescent technique provided significantly superior early graft uptake (day 5) and donor site healing (day 10) compared with the non-tumescent technique, while 3-week outcomes were comparable. Both techniques are safe and effective, and the choice should be individualised to surgeon preference, wound characteristics, and intra-operative considerations.

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