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Original Article

Surgery Section

Surgical Outcome of Tumescent Versus Non Tumescent Technique for Harvesting Split Skin Graft: A Prospective Cohort Study

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ABSTRACT

Introduction: The technique for harvesting Split-thickness Skin Grafts (STSG) varies among surgeons. To control bleeding from split-thickness skin graft donor sites, the use of several haemostatic agents has been reported. The tumescent technique involves injecting tumescent fluid into the subcutaneous fat, obtaining swelling and firmness (tumescence) of the surgical area. This creates regional anaesthesia of the skin and subcutaneous tissue, allowing painless cutaneous surgery, with adrenaline acts as a haemostatic agent.

Aim: To compare the surgical outcomes in terms of blood loss during the harvesting of STSG, postoperative pain experienced by the patient, healing of the donor site, and graft take rate with tumescent versus non tumescent techniques of STSG.

Materials and Methods: The present prospective cohort study was conducted in the Department of General Surgery, M S Ramaiah Medical College, Bengaluru, Karnataka, India, from November 2017 to March 2019. A total of 56 patients were enrolled after applying inclusion and exclusion criteria. Patients were alternately assigned into the groups of tumescent or non tumescent technique groups. Intraoperative bleeding was assessed, postoperative pain was assessed using the Visual Analogue Score (VAS), and healing of the donor and recipient sites were assessed. Student's t-test (two-tailed, independent) was used to find the significance of study parameters on a continuous scale between the two groups. The Chi-square/ Fisher's-exact test was used to assess the significance of study parameters on a categorical scale between two or more groups.

Results: The mean±Standard Deviation (SD) age of patients in the tumescent group was 48.25±12.79 years and in the non tumescent group was 52.79±12.91 years. Intraoperative bleeding ranged from 0-25% in all 28 patients in the tumescent group, while it ranged from 76-100% in all 28 patients in the control group (p-value<0.001). When the authors compared the pain on Postoperative Day (POD) 1 using VAS we observed that 32.1% of cases (n=9) had a score of 5-7 compared to 28.6% of controls (n=8). There was no significant difference in postoperative pain, and the technique used for harvesting STSG did not affect the healing of the donor site or the graft take at the recipient site.

Conclusion: The tumescent technique is a safer and better alternative to the non tumescent technique, as intraoperative bleeding is significantly lower with the former. Additionally, the tumescent technique does not affect the healing of the donor or recipient site.

Keywords: Dermatoplasty, Skin grafting, Skin transplantation

INTRODUCTION

Skin grafting, a time-honoured surgical technique, has been utilised across generations to cover wounds. It is a fundamental procedure in modern surgical practice, with applications ranging from treating burns and injuries to managing chronic wounds. Skin grafting is pivotal in restoring both the appearance and functionality of damaged or compromised skin [1]. Pain and bleeding are the main concerns associated with skin grafting. To control bleeding from split-thickness skin graft donor sites, the use of several haemostatic agents has been reported. Most of these agents are applied to the wound surface after graft harvesting. However, even with these methods, initial bleeding just after graft harvesting cannot be avoided [2].

The advent of tumescent anaesthesia in cutaneous surgery has given rise to bloodless and painless surgery, in addition to reduced postoperative swelling and bruising [3]. The tumescent technique has evolved over the past 20 years, mainly for use in liposuction [4]. Tumescent Local Anaesthesia (TLA) is a method that achieves comprehensive regional anaesthesia by infusing a diluted local anaesthetic solution directly into the subcutaneous tissue. It was innovated by Dr. Jeffrey Klein in 1987, who employed significant amounts of a diluted lidocaine and adrenaline solution for fat infiltration before conducting liposuction procedures [5]. This method has found extensive application across a spectrum of both cosmetic and non cosmetic procedures, ranging from laser dermatological surgery to brachioplasty, abdominoplasty and hair transplant surgeries, face-lifts, breast augmentation and extraction of skin grafts [6-8].

Yet, the incorporation of the tumescent technique in STSG has been limited, largely due to insufficient data regarding the graft's viability, particularly following the use of adrenaline. Literature on the local and systemic effects of adrenaline presents differing views. Some authors contend that its effects are brief and insignificant, while others express concerns about its potential adverse effects on both the harvested graft and the healing of the donor site [9]. Hence, it is imperative to explore the effectiveness of the tumescence technique in harvesting STSG compared to the conventional method.

MATERIALS AND METHODS

This was a prospective cohort study was conducted in the Department of General Surgery, M S Ramaiah Medical College, Bengaluru, Karnataka, India, from November 2017 to March 2019. After taking Institutional Ethical Committee approval (SS-1/EC/034/2017), all patients admitted to the Department of General Surgery with a diagnosis of a healing ulcer posted for STSG were considered for the study. Patients who fulfilled the inclusion and exclusion criteria were explained about the advantages and disadvantages of both techniques, and written informed consent was taken.

Sample size calculation: Based on a previous study by Shariff N et al., it was found that the intraoperative bleeding was 7.80±0.712 mL (mean±SE) in the test group and 11.80±0.752 mL (mean±SE) in the control group [10]. Considering a similar difference, with a power of 80% and an alpha error of 5%, the sample size was calculated to be 28 in each group.

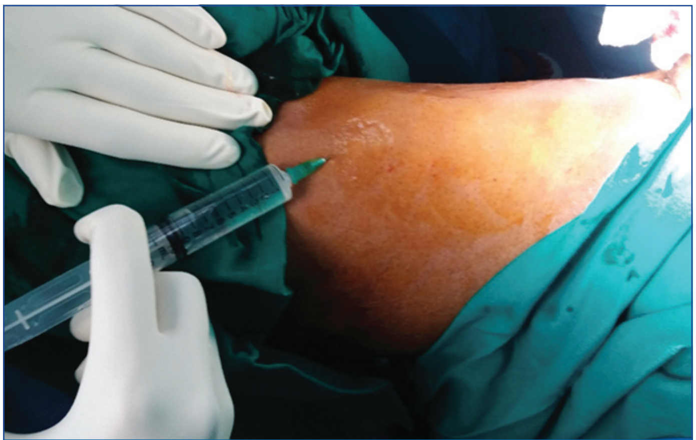
Inclusion criteria: Patients aged ≥18 years with healing ulcers were included in the study.

Exclusion criteria: Patients with co-morbidities (like cardiac diseases, vasculitis, renal failure, liver disease), immunosuppressed patients, patients allergic to adrenaline, ulcers that grew β-haemolytic streptococci on culture and patients who refused consent were excluded from the study.

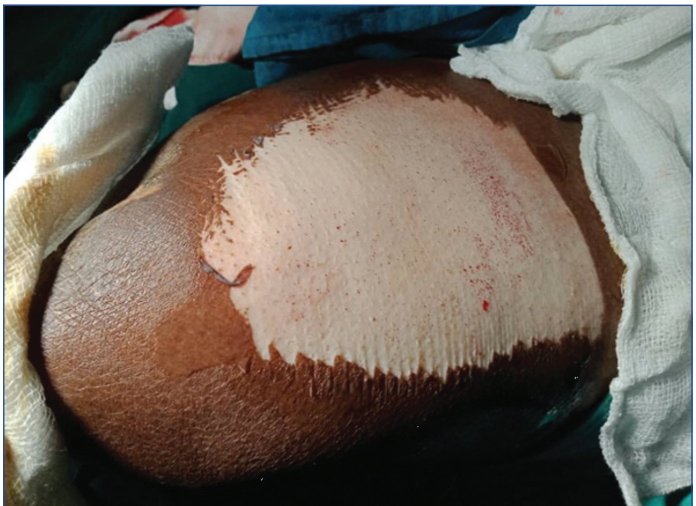
Study Procedure

Patients were alternately assigned to the tumescent and non tumescent groups. Data was collected using a preformed proforma. A detailed history of the patients along with their clinical examination was recorded. A culture sensitivity swab was taken from the ulcer to know the organism, if any infecting the ulcer.

Tumescent technique: Klein's formula containing 0.1% lidocaine, sodium bicarbonate 12.5 mEq (12.5 mL of 8.4% $NaHCO_3$), and 1:1 million adrenaline in 1 litre of saline was used and injected subcutaneously at the donor site [Table/Fig-1,2].



[Table/Fig-1]: Injection of tumescent fluid at the donor site.



[Table/Fig-2]: Donor site after injecting tumescent fluid.

Non tumescent technique graft was taken without injecting a tumescent agent [Table/Fig-3]. In both groups, STSG was harvested using a humby (hand-held) knife. The grafts underwent manual meshing with an 11-number scalpel before being placed over the prepared recipient area. They were then affixed in position using sutures. The grafts were covered with burn mesh, and dressing was applied. Similarly, the donor area was also covered with burn mesh, and dressing was applied.

[Table/Fig-3]: Donor site, where no tumescent fluid was injected.

The parameters assessed were: 1) Blood loss from the donor site, which was gauged by placing a standard OT gauze piece on the donor site immediately after harvesting and then spreading it out on a scale bearing 1 cm^2 and counting the number of squares whose area was ≥50% covered by the blood-soaked gauze piece. This was matched with the total number of squares that the gauze piece covered [10]; 2) postoperative pain on POD-1 was analysed using VAS; 3) healing of the donor site was assessed in terms of epithelialisation occurring on PODs 10 and 15; and 4) healing of the recipient site in terms of graft take on PODs 5, 10 and 15.

STATISTICAL ANALYSIS

In the present study, the authors have done both descriptive and inferential statistical analyses. Results based on metric measurements were presented as mean±SD, while results of categorical measurements were presented as frequencies and percentages. A Student's t-test (two-tailed, independent) was used to find the significance of study parameters on a continuous scale between two groups (intergroup analysis) for metric parameters. Leven's test for homogeneity of variance was performed to assess the homogeneity of variance. The Chi-square/Fisher's-exact test was used to find the significance of study parameters on a categorical scale between two or more groups. A p-value of ≤0.01 was considered significant. Statistical Package for the Social Sciences (SPSS) software version 18.0 was used for the data analysis.

RESULTS

A total of 56 patients were alternatively divided into the tumescent and non tumescent control groups, with 28 patients in each group. The mean age of patients in the tumescent group was 48.25 years with a SD of 12.79 years, and in the non tumescent group was 52.79 years with a SD of 12.91 years, and they were comparable in both groups [Table/Fig-4]. Within the tumescent group, 19 (67.9%) patients were males and 9 (32.1%) were females, while in the non tumescent group, there were 18 (64.3%) males and 10 (35.7%) females [Table/Fig-5]. Among the tumescent group, 25 (89.3%) of the ulcers were located on the lower limb, 2 (7.1%) on the upper limb, and 1 (3.6%) elsewhere, specifically, one on the penile shaft. Among the non tumescent group, 26 (92.9%) of the ulcers were located on the lower limb, 1 (3.6%), on the upper limb, and 1 (3.6%) elsewhere [Table/Fig-6].

Age (years)	Cases, n (%)	Controls, n (%)	Total, n (%)
21-30	3 (10.7)	2 (7.1)	5 (8.9)
31-40	3 (10.7)	3 (10.7)	6 (10.7)
41-50	10 (35.7)	5 (17.9)	15 (26.8)
51-60	7 (25)	10 (35.7)	17 (30.4)
61-70	4 (14.3)	7 (25)	11 (19.6)
71-80	1 (3.6)	1 (3.6)	2 (3.6)
Total	28 (100)	28 (100)	56 (100)
Mean±SD	48.25±12.79	52.79±12.91	50.52±12.93

[Table/Fig-4]: Age distribution of the patients studied.
p-value=0.192; Student's t-test

Gender	Cases, n (%)	Controls, n (%)	Total, n (%)
Male	19 (67.9)	18 (64.3)	37 (66.1)
Female	9 (32.1)	10 (35.7)	19 (33.9)
Total	28 (100)	28 (100)	56 (100)

[Table/Fig-5]: Gender distribution of the patients studied.
p-value=0.778; Chi-square test

Site of ulcer	Cases, n (%)	Controls, n (%)	Total, n (%)
Upper limb	2 (7.1)	1 (3.6)	3 (5.4)
Lower limb	25 (89.3)	26 (92.9)	51 (91.1)
Elsewhere	1 (3.6)	1 (3.6)	2 (3.6)
Total	28 (100)	28 (100)	56 (100)

[Table/Fig-6]: Site of ulcer distribution.
p-value=1.000; Not significant; Fisher-exact test

The percentage of a standard gauze piece, soaked with blood intraoperatively while harvesting the STSG, was 0-25% in all (n=28) the patients in the tumescent group and 76-100% in all the 28 patients in the non tumescent group. The p-value is <0.001 [Table/Fig-7].

% of gauze soaked with blood intra-op	Cases, n (%)	Controls, n (%)	Total, n (%)
0-25%	28 (100)	0 (0)	28 (50)
26-50%	0	0	0
51-75%	0	0	0
76-100%	0	28 (100)	28 (50)
Total	28 (100)	28 (100)	56 (100)

[Table/Fig-7]: Percentage of a standard gauze piece placed on the donor site and soaked with blood intraoperatively, while harvesting the STSG.
P<0.001** significant; Fisher-exact test

There was no significant association between the tumescent technique and the pain of the patient on POD-1 [Table/Fig-8]. All the patients in the tumescent group, as well as, the non tumescent group showed 100% epithelialisation of the donor site by POD-10 and 15 [Table/Fig-9].

The graft take shows 76-100% in 20 (71.4%) in the tumescent group by POD-5 compared to 22 (78.6%) patients in the non tumescent group [Table/Fig-10]. A total of 21 (75%) patients in the tumescent group showed a 76-100% graft take by POD-10 as opposed to 23 (82.1%) in the non tumescent group [Table/Fig-11]. A total of 82.1% of the patients in the case group showed a 76-100% healing of the recipient site by POD-15 as opposed to 89.3% of the patients in the control group [Table/Fig-12].

Pain on POD-1 as per VAS	Cases, n (%)	Controls, n (%)	Total, n (%)
0-4	0	0	0
5-7	9 (32.1)	8 (28.6)	17 (30.4)
8-10	19 (67.9)	20 (71.4)	39 (69.6)
Total	28 (100)	28 (100)	56 (100)

[Table/Fig-8]: Pain on POD-1.
p-value=0.771; Not significant; Fisher-exact test

% of donor site epithelialisation by POD-10 and POD-15	Cases, n (%)	Controls, n (%)	Total, n (%)
0-25%	0	0	0
26-50%	0	0	0
51-75%	0	0	0
76-100%	28 (100)	28 (100)	56 (100)
Total	28 (100)	28 (100)	56 (100)

[Table/Fig-9]: Percentage of donor site epithelialisation by postoperative day 10 and 15.
p-value=1.000; Not significant; Fisher-exact test

% of graft take by POD-5	Cases, n (%)	Controls, n (%)	Total, n (%)
0-25%	2 (7.1)	0	2 (3.6)
26-50%	0	1 (3.6)	1 (1.8)
51-75%	6 (21.4)	5 (17.9)	11 (19.6)
76-100%	20 (71.4)	22 (78.6)	42 (75)
Total	28 (100)	28 (100)	56 (100)

[Table/Fig-10]: Percentage of graft take by POD-5.
p-value=0.515; Not significant; Fisher-exact test

% of recipient site healed by POD-10	Cases, n (%)	Controls, n (%)	Total, n (%)
0-25%	2 (7.1)	0	2 (3.6)
26-50%	0	1 (3.6)	1 (1.8)
51-75%	5 (17.9)	4 (14.3)	9 (16.1)
76-100%	21 (75)	23 (82.1)	44 (78.6)
Total	28 (100)	28 (100)	56 (100)

[Table/Fig-11]: Percentage of recipient site healed by POD-10.
p-value=0.494, Not significant, Fisher-Exact Test

% of recipient site healed by POD-15	Cases, n (%)	Controls, n (%)	Total, n (%)
0-25%	2 (7.1)	0	2 (3.6)
26-50%	0	0	0
51-75%	3 (10.7)	3 (10.7)	6 (10.7)
76-100%	23 (82.1)	25 (89.3)	48 (85.7)
Total	28 (100)	28 (100)	56 (100)

[Table/Fig-12]: Percentage of recipient site healed by POD-15.
p-value=0.589; Not significant; Fisher-exact test

None of the patients in either the case or the control group developed a haematoma or seroma at the recipient site.

DISCUSSION

The STSG is one of the most commonly performed procedures in General Surgery practice, with several methods available for harvesting the graft. Various types of freehand knives are also available for split grafting. The thickness of the graft is dependent on factors such as the angle of movement, pressure applied, as well as, the distance between the blade and the roller bar. The most common technique involves the use of a gas-driven or electric dermatome, in which a thin, sharp blade oscillates at high speed within an enclosed rectangular space as the machine is moved along the skin. By changing the gauge that determines the distance between the moving blade and its rigid superstructure, grafts of varying thickness can be taken [11]. However, concerns regarding donor site bleeding and pain was a concern. The effectiveness of the solution (rule of four) in reducing bleeding, in the anaesthetic action, and stabilising blood pressure during and after surgery has been proven in over 1,000 procedures in various body regions. It has been used in tumour excisions with direct closure or with flaps, dermabrasion, elevation, and removal of zit scarring, cryosurgery, after curettage and electrocoagulation, or CO_2 laser vaporisation on the scalp, face, arms and legs [12,13].

In the present study, baseline data including age, sex and laterality of the ulcer were comparable. The tumescent technique is one way of minimising iatrogenic blood loss. In a study by Shariff N et al., the reduction in blood loss among the tumescent group compared to the non tumescent group was statistically significant, i.e., p-value<0.003 [10]. Robertson RD et al., conducted a case-control study where the tumescent technique significantly reduced blood loss during burn surgery [13]. Fujita K et al., reported a study showing successful excision of burn scar with no intraoperative bleeding [14]. The tumescent technique significantly reduced blood loss in a study conducted by Prasad MK et al., [8]. Adrenaline is used in the tumescent technique of harvesting skin grafts due to its vasoconstriction effect, which limits blood loss.

In the current study, when the authors analysed pain on the first POD, there was not much difference. However, in a study by Shariff N et al., on POD-1, 68% of patients had less pain with the tumescent solution injected at the donor site compared to no fluid [10]. But there was no difference in pain on POD-3 in their study [10]. In a study by Blome-Eberwein S et al., pain reported on day 1 was 2.38/10 in the tumescent site and 3.38/10 in the saline site (p-value=0.21). On other days, there was no significant difference [15]. Gacto P et al., study showed reduced postoperative pain in donor-site injected tumescent fluid versus saline [16].

The percentage of healing with the use of the tumescent technique was statistically significant and higher when compared to the non tumescent technique, indicating a higher healing rate (p-value=0.0134) [3]. However, in a study by Fukuoka K et al., donor sites were healed with no significant difference between the tumescent and non tumescent groups [2]. In the present study, both groups showed epithelisation and healed by day 10 and 15.

There was no significant difference in graft take in the recipient site and healing in both groups in the present study on days 5, 10 and 15. In a study by Anandaravi BN et al., the mean graft take-up rate in the tumescent method of harvesting split skin graft was 98.1%, and that of the non tumescent method was 86.1%, which was statistically significant [17]. A study conducted by Cartotto R et al., found that the viability of the harvested graft is not affected by the tumescent technique [18]. There are not many studies done on the effect of the tumescent technique of graft harvesting on graft take and recipient site healing. The present study shows that in both groups, the graft uptake and recipient area healing were unaffected.

Limitation(s)

The sample size is small, and it is a single centre study, which may limit the generalizability of the findings. A short follow-up period is another limitation. Longer follow-up periods would allow for the evaluation of outcomes over a more extended period and provide a more comprehensive understanding of the intervention's effectiveness. The lack of blinding, randomisation and absence of control for confounding factors such as co-morbidities, medication use, or wound characteristics impact the interpretation of the results.

CONCLUSION(S)

Tumescent technique is a safer and better alternative to non tumescent technique as the intraoperative bleeding is significantly lower in the former. It also does not affect the healing of the donor or the recipient site. However, further prospective and randomised study with larger sample size is recommended for a definitive conclusion.

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