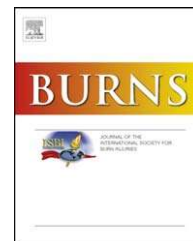


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Management of split-thickness skin graft donor site: A prospective clinical trial for comparison of five different dressing materials

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ABSTRACT

Introduction: Split-thickness skin grafting (STSG) is a frequently used reconstructive technique but is associated with a large variation regarding the management of the donor site. The aim of this study is to compare five different dressings for management of the STSG donor site in a prospective trial.

Patients and methods: 100 consecutive patients, in whom reconstruction with STSG was performed, were included into the study. The grafts are harvested in a standard manner and the donor sites were dressed with one of the following materials: Aquacel[®] Ag, Bactigras[®] with Melolin[®], Comfeel[®] Plus Transparent, Opsite[®] Flexigrid and Adaptic[®]. The materials are compared regarding to the time required for complete epithelialization, pain sensed by the patients, incidence of infection, scar formation, ease of application and the cost.

Results: The earliest complete epithelialization was observed for Aquacel[®] Ag and the latest for Bactigras[®] with Melolin[®]. Comfeel[®] Plus Transparent was the most painless dressing and Bactigras[®] with Melolin[®] was the most painful. The incidence of infection was highest for Bactigras[®] with Melolin[®]. Opsite[®] Flexigrid was the most economical dressing and Aquacel[®] Ag was the most expensive one.

Conclusion: The aim is to provide the earliest complete epithelialization with minimal patient discomfort and lower cost in management of the STSG donor sites. None of the tested materials were ideal regarding these criteria, but Comfeel[®] Plus Transparent, as the least painful and one of the most economical materials, may be offered as the dressing of choice among the tested materials.

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1. Introduction

Reconstruction with split-thickness skin grafts (STSG) is one of the most frequently practiced procedures in plastic surgery, as a fundamental step in the reconstructive ladder. Although the dressings applied to the recipient sites of the grafts are standard and universally accepted, the ideal dressing material for handling of the donor site is yet to be developed and extensive variability exists in the management of STSG donor

sites. New dressing materials are developed every year with better understanding of the mechanisms of wound healing and with the reinforcement of the advanced technology, and these new products that are intended to speed healing and reduce pain, further contribute to practice variation [1,2].

Bactigras[®] with Melolin[®] had been the standard dressing material used for management of the STSG donor sites for the last few years at this plastic surgery unit due to availability, low cost and ease of appliance. After analyzing the nursing

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questionnaires, that are regularly performed and aimed to reveal the pleasure and complaints of the patients, it was disclosed that all of the patients reconstructed with STSG, complained of the pain and discomfort at their donor sites. Even for the ones with large tissue defects, or the ones with free flap reconstructions, donor sites of the STSG were the primary cause of distress for the patients.

This prospective trial is designed in order to find out another dressing material, if available, to reduce the complaints of our patients and to optimize the management of STSG donor sites. Four dressing materials with different functional and chemical constitution were compared with the currently used one, with regard to pain and discomfort sensed by the patients, time required for epithelialization of the donor site, long-term scar formation, incidence of infection and ease of appliance by the surgical staff, as well as the cost of the material.

2. Patients and methods

This prospective trial was started in February 2006 to include 100 consecutive patients in whom reconstruction with STSG larger than 10 cm² was needed. The patients with donor sites other than thigh and with formerly used graft donor sites, pediatric patients younger than 16 years of age and senile or in-cooperated patients were all excluded out of this study.

All of the grafts were harvested in a standardized manner from antero-lateral or posterior thigh region by one of three surgeons by using a powered dermatome (Acculan Dermatomy, Aesculap Power Systems, Aesculap Inc., PA, USA) adjusted to 0.2 mm thickness. The hemostasis was provided by dressing with a wet gauze for 15 min before the actual dressing.

One type of material was used per patient. The materials were numbered between 1 and 5, and used in this sequence for the initial five patients. This order was continued for the consecutive patients till the end of the study. Due to problems of availability, Bactigras[®] with Melolin[®] was used for the patients in whom Adaptic[®] was assigned for the last 4 occasions. The materials tested are listed below and described in detail in Table 1:

1. Aquacel[®] Ag (ConvaTec), no.: 20 patients.
2. Bactigras[®] with Melolin[®] (Smith & Nephew), no.: 24 patients.
3. Comfeel[®] Plus Transparent (Coloplast), no.: 20 patients.
4. Opsite[®] Flexigrid (Smith & Nephew), no.: 19 patients.
5. Adaptic[®] (Johnson & Johnson), no.: 14 patients.

All of the materials were supported with gauze pads and bandages as external dressing. The external supportive dressings were changed at postoperative 4th day, excluding the ones with findings of infection such as purulent discharge, bad odor or incredible pain. The external supportive dressings were changed with two days intervals thereafter until the epithelialization is completed, during when the primary dressing is not renewed. In case of a suspicion for infection, the primary dressing was removed, the donor site is evaluated with inspection and the cultures of the purulent discharge

were taken. The primary dressings were renewed daily in these patients.

The dressing materials were compared according to the following criteria:

1. The time required for epithelialization of more than 90% of the donor site.
2. Pain scored with VAS (Visual Analogue Scale) at post-operative days 4, 7 and 14.
3. Long-term scar quality scored with VSS (Vancouver Scar Scale).
4. Ease of application of the material assessed by the surgical staff.
5. Clinical findings of infection at the donor site, such as erythema, induration, incredible pain, purulent discharge or bad odor.
6. Cost of the dressing per cm² (excluding the complications).

The donor site was accepted as healed whenever the epithelialization was more than 90 percent, without infection and without pain on exposure to air. The time of completed epithelialization was determined with inspection in donor sites dressed with transparent materials. In other materials, the criteria was the possibility of ease and painless removal or self-removal of the dressing.

The patients scored pain at their STSG donor sites between 0 (no pain) and 10 (incredible pain) with VAS at 4, 7 and 14 days, at the same time of the day and after 30 min of bed-rest (for mobile patients).

The patients were followed at least for 6 months post-operatively for evaluation of the scar tissue at the donor site using VSS. This scale is scored by the same physician (C.Y.) for all of the patients according to elasticity of the donor site skin (0–5), the height from peripheral normal skin (0–3), vascularization (0–3) and pigmentation (0–3) [9].

The ease of appliance was scored by 15 staff (12 physicians and 3 nurses) at the plastic surgery unit who participated to the appliance of the five materials studied, between 0 (useless due to difficulty of application) and 10 (the easiest appliance ever possible).

The Statistical Package for the Social Sciences (SPSS) for Windows (SPSS Inc., Chicago, IL), version 13.0, was used for statistical analysis. Frequency data were presented as percentages and numerical data were expressed as means with standard deviation (SD). The distribution pattern of all measured data was evaluated for comparison. These data did not conform to normal distribution even after logarithmic transformation and therefore, the statistical assessment was done with Kruskal–Wallis test. Tests and significance was investigated with Bonferroni corrected Mann–Whitney U test for paired comparisons. Chi-square test was used for comparison of the frequency data. $p < 0.05$ was accepted as statistically significant.

3. Results

Three patients died during follow-up and the evaluation was possible in 97 patients. The mean age of the patients was 48.3 years with a range of 17–84 years. The mean area of the donor

Table 1 – Distinctive aspects of each dressing material according to the results of the study and definitions acquired from the official web sites of the manufacturers.

Dressing materials	Dressing type	Transparency	Self-adhesiveness	Occlusive environment	Absorption capacity	Definitions ^a
Comfeel [®] Plus Transparent	Hydrocolloid	Yes	Yes	Yes	Moderate	A highly absorbent, self-adhesive hydrocolloid dressing. The superior exudate management is due to absorption and the semi-permeable polyurethane top film. It is thin, soft, and flexible and nerve endings are effectively protected by the gel formed by the absorbent mass [3].
Aquacel [®] Ag	Unclassified	No	No	No	High	Dressing incorporating gelling characteristics of Hydrofiber [®] technology with the broad spectrum antimicrobial properties of ionic silver. Releases ionic silver in a controlled manner as wound exudate is absorbed into the dressing and supports wound healing by providing a moist healing environment [4].
Opsite [®] Flexigrid	Poly-urethane film	Yes	Yes	Yes ^b	No	It is a transparent, polyurethane adhesive film, moisture vapor permeable, conformable and extensible, retains wound contact with the natural wound exudate and provides an environment for safer and less painful wound healing. The high moisture vapor permeability allows excess exudate to evaporate [5].
Adaptic [®]	Cellulose based	No	No	No	No	Primary dressing made of knitted cellulose acetate fabric and impregnated with a specially formulated petrolatum emulsion. Dressing is indicated for dry to heavily exuding wounds where adherence of dressing and exudate is to be prevented [6].
Bactigras [®] with Melolin [®]	Tulle gras	No ^c	Yes ^c	No	High ^d	Bactigras [®] is a low-adherent antimicrobial tulle gras dressing with soft paraffin base containing Chlorhexidine acetate, an antiseptic with a broad spectrum, allows the wound to drain freely into an absorbent dressing. Melolin [®] used in this study for this purpose is a highly absorbent non-adhering dressing [7,8].

^a Definitions acquired from the official web sites of the manufacturers.^b Gelling characteristic of Aquacel[®] Ag provides an occlusive environment.^c Bactigras[®] is transparent and adheres to the wound.^d Melolin[®] is highly adsorptive.

sites was $207.1 \pm 85.3 \text{ cm}^2$ with a range of 12 cm^2 ($3 \text{ cm} \times 4 \text{ cm}$) and 448 cm^2 ($28 \text{ cm} \times 16 \text{ cm}$). The etiology of the recipient wounds was chronic ulcer in 24 patients, tumor resection in 19, burn in 17, trauma in 16, secondary complications of a previous surgery in 16 and necrotizing infections in 5 patients. The mean area of the donor site, the mean age of the patients and distribution of the patients according to the etiology were statistically similar among the 5 groups of dressing materials tested. No significant difference among the groups was yielded from the assessment of the scars with VSS (Table 2).

An overall scoring system integrating the major parameters studied (average ranks of epithelialization, pain, infection, ease of application and cost) was used to rank the performance of the dressing materials in the management for STSG donor sites. For each of the parameters, three stars are assigned to the best performance, two stars to the moderate performance and one star to the weakest performance (Table 3). Distinctive aspects of each material, compiled from the findings of this study are mentioned below and in Table 1. The dressings are ranked in decreasing order of the total score:

1. *Comfeel® Plus Transparent* (12): Representative of the hydro-colloid dressings. Transparency of the material facilitated the observation of the donor site. Self-adhesiveness is another advantage sustaining the occlusive environment, but this feature is useless unless the peripheral skin of the donor site is dry during application. Furthermore, the dressing separates from the wound if the exudate exceeds the absorption capacity of the dressing and leaks through the borders. This situation existed in two patients throughout this study. Showed the best performance in reduction of the pain and the cost. The mean score was 0.8/10 on 7th day VAS evaluation of pain and this was the lowest score among the materials tested. The difference was statistically significant compared to all other dressings ($p < 0.001$). Demonstrated moderate performance for other parameters, with no weakest score at all.
2. *Aquacel® Ag* (11): This is a unique material having superior features of different groups of materials and thus difficult to classify. It is not self-adhesive but when in contact with the wound, immediately absorbs water and gels (the glove of the applier must be dry for untimely gelling). This gelling characteristic provides an occlusive environment for the wound as well as a splint effect which further increases the comfort of the patient. It was the best for providing the soonest epithelialization and second best for ease of application. Ninety percent epithelialization was obtained soonest in the donor sites dressed with *Aquacel® Ag*, with a mean duration of 8.1 ± 0.9 days (range: 7–10 days) and the difference was statistically significant ($p = 0.001$) in comparison with all other dressings. Showed moderate performance for other parameters, except the cost; it was the most expensive dressing. Note that *Aquacel® Ag* lost the first rank due to its high cost.
3. *Opsite® Flexigrid* (10): Represented the polyurethane film dressings. Self-adhesive but requires a strictly dry peri-wound skin for effective occlusion. Exudate usually leaks through a border due to non-absorptive feature of the material and contaminates the external dressing. The dressing was totally separated from the wound on four

Table 2 – The results of the comparison between groups. Statistical significance was obtained for four measures (*, **, *, ****) which are expressed in bold.**

Dressing materials	Mean age (years)	Mean area of donor site (cm^2)	Days for 90% epithelialization	VAS at day 4	VAS at day 7	VAS at day 14	VSS	Ease of application	Incidence of infection	The cost of dressing (\$/ cm^2)
<i>Aquacel® Ag</i>	50.5 (18.2)	184 (87)	8.1 (0.9)*	2.5 (1.1)	2.2 (1)	1.2 (0.9)	2.4	8.9 (0.7)	1/20	0.155
<i>Bactigras® with Melolin®</i>	48.3 (16.6)	220 (121)	10.5 (2.4)	4.5 (2.2)**	2.7 (1.5)	1.2 (0.7)	2.3	9.0 (0.8)	3/24	0.025
<i>Comfeel® Plus Transparent</i>	49.4 (19.1)	221 (84)	9.6 (1.6)	2.0 (2.1)	0.8 (1.2)**	0.9 (0.8)	2.2	7.2 (1.3)	1/20	0.017
<i>Opsite® Flexigrid</i>	44.2 (15.3)	199 (45)	9.5 (1.7)	2.8 (2.2)	2.1 (1.4)	1.6 (1.2)	2.6	4.5 (2.0)***	1/19	0.014
<i>Adaptic®</i>	44.7 (15.6)	210 (45)	9.8 (1.5)	3.0 (1.1)	2.6 (1.3)	1.8 (0.9)	2.7	6.1 (1.9)	1/14	0.055

SD (standard deviation) is presented in brackets.

* $p = 0.001$.

** $p = 0.002$.

*** $p < 0.001$.

**** $p < 0.001$ compared with all other dressings.

Table 3 – Quantification and ranking of the dressings according to total scores (For each of the parameters, three stars are assigned to the best performance, two star to the moderate performance and the one star to the weakest performance).

Dressing materials	Time for 90% epithelialization	VAS scores	Ease of application	Incidence of infection	The cost of dressing	Total score
Comfeel [®] Plus Transparent	**	***	**	**	***	12
Aquacel [®] Ag	***	**	***	**	*	11
Opsite [®] Flexigrid	**	**	*	**	***	10
Adaptic [®]	**	*	**	**	**	9
Bactigras [®] with Melolin [®]	*	*	***	*	**	8

occasions. Transparency is an advantage for observation of the epithelialization. It was the cheapest dressing used in this study, but it was scored 4.5/10 as the least easily applied dressing ($p < 0.001$). Demonstrated moderate performance for other parameters.

4. *Adaptic[®]* (9): Cellulose based non-adhesive dressing. The distinctive characteristic is that it never sticks to the wound, although a beneficial feature regarding the wounds requiring frequent dressing changes, cause difficulties during application. No best performance for any of the parameters, but one of the most painful dressings. Moderate scores for other four considerations.
5. *Bactigras[®] with Melolin[®]* (8): It adapts well to the wound and easily shaped. Impregnation of the paraffin is inadequate and the most of it is left in the package during application. One of the most easily applied dressings, but offered the latest epithelialization with a mean duration of 10.5 ± 2.4 days (range: 8–16 days), and the most painful dressing with the highest incidence of infection. The highest mean score of 4.5/10 on 4th day VAS evaluation of pain belonged to *Bactigras[®] with Melolin[®]* group and this difference was statistically significant compared to other dressings excluding *Adaptic[®]* ($p = 0.002$).

The materials were also compared as occlusive (*Aquacel[®] Ag*, *Comfeel[®] Plus Transparent* and *Opsite[®] Flexigrid*) and semi-occlusive (*Bactigras[®] with Melolin[®]* and *Adaptic[®]*) dressings. The mean time for complete epithelialization was 9.1 ± 1.6 days for occlusive dressings and 10.2 ± 2.1 days for semi-occlusive dressings with a statistically significant difference between the groups ($p = 0.005$). The mean scores of VAS were significantly lower for occlusive dressings at both 4th (2.5 ± 1.8 vs 4.0 ± 2.1) and 7th day (1.7 ± 1.4 vs 2.6 ± 1.4) evaluations compared with the semi-occlusive ones ($p = 0.01$).

4. Discussion

Donor site for STSG lacks the entire epidermis and a variable depth of dermis, and the healing is achievable only with epithelialization. The features of the ideal dressing material for STSG donor sites should include the ability to create the suitable environment for epithelialization, reduction of pain and discomfort, preventing infection, absorbing the exudates, being easily applicable and economical in cost [10–12]. Recently, better understanding of the factors influencing the wound healing inspired development of new dressing materials with the aid of modern technology. But the most ideal dressing material for the donor sites of STSG is not yet generated [13].

Dressing materials have a broad range of chemical and physical structure and principally classified as occlusive, semi-occlusive and non-occlusive according to their ability to create a closed environment on the wound [14]. It is known that the epithelialization is completed earlier when the occlusive or semi-occlusive dressings providing a wet environment are used, in comparison with open and dry dressings [10,15,16]. Occlusive and semi-occlusive dressings provide the best protection for the wound from dehydration, contamination and mechanical trauma and thus facilitate the healing [14]. Non-occlusive dressings, therefore, are not preferred for uncomplicated STSG donor sites anymore. Based on the findings of this trial, it is further alleageable that occlusive dressings surpass the semi-occlusive equivalents for management of the STSG donor sites in many aspects (Table 2).

Pain in the skin is transmitted to the central nervous system via the free nerve endings located at the dermis serving as receptors of nociceptor neurons located at the dorsal root ganglia. Many of these nerve endings are injured and exposed to external stimuli in STSG donor site and many minute stimuli are converged and sensed as an augmented pain. Thus, the pain of the donor site is much more aggravated than the recipient site. The occlusive environment is thought to reduce pain by preventing the exposure of free nerve endings to air [17]. Additionally, occlusive dressings reduce the oxygen concentration, which in turn decrease the accumulation of the arachidonic acid metabolites in the environment that are also thought to aggravate the sensation of pain [18].

All of the patients routinely received intravenous or intramuscular injections of analgesics during the first three days after operation and the evaluation of pain with VAS was thought to be misleading during this period. The analgesic drugs were ordered on demand, thereafter, and VAS inquiry began at the fourth postoperative day. The patients scored VAS in the morning, at the same time, before any type of analgesia is applied, if needed.

The common feature of the selected four materials in this study was that they were all suggested as the dressing of choice for STSG donor sites in at least one of several different studies performed previously [19–24]. *Aquacel[®] Ag* offered the earliest epithelialization in this study, probably related to its chemical and physical composition [19]. Although not self-adhesive as *Comfeel[®] Plus Transparent* and *Opsite[®] Flexigrid*, it immediately forms a fibrin layer over the wound keeping the intrinsic growth factors and cytokines in the environment [15,25,26]. The highly absorptive hydrocolloid polymer structure aids removal of the excess exudate while providing a moist environment. This feature distinguishes the material from other non-absorptive dressings providing an occlusive environment. Despite the asserted antimicrobial effect of embedded silver

ions, the rate of infection was comparable to other occlusive dressings [27]. The effect of occlusive environment on the incidence of infection in STSG donor sites is controversial [28,29]. The occlusive dressings have the advantage of preventing external contamination, with the disadvantages of causing maceration and leakage of the exudates (except Aquacel[®] Ag in this study) [14,30,31]. The number of infections was highest for Bactigras[®] with Melolin[®]. The incidence of infection was one patient per group for other dressings, confirming the superiority of the occlusive dressings in hydrogel and hydrocolloid nature for this function [11,13,29,32,33].

One of our observations during the study has been that self-adhesive occlusive dressings (Comfeel[®] Plus Transparent and Opsite[®] Flexigrid), when applied before the donor site is completely dried up, do not effectively adhere to the site and occasionally separate. The dressings are useless anymore if the adhesive layers get wet, thus the application calls for greater attention when compared to other materials. Excluding this initial concern, the incidence of unscheduled renewal of the external dressing was statistically similar between the occlusive (no.: 7/59) and the semi-occlusive (no.: 5/40) groups.

The cost of the materials differed in a broad range; Opsite[®] Flexigrid offering the most economical management. Aquacel[®] Ag, being 3–10 times costly than the former materials per cm², was the most expensive dressing. Hypertrophic scar was detected in 3 patients each from different groups. This result did not yield a statistical significance between the dressing materials.

The sample size of this particular study has been adequate for determination of the superior dressing materials regarding epithelialisation and VAS, but higher orders of magnitude would be needed for evaluation of scar formation and infection. Therefore, larger definitive and randomized trials based on the findings presented here are needed to differentiate the efficacy of these materials in prevention of infection and on long-term scar formation.

5. Conclusion

The efficiency of the occlusive environment on healing of the donor site and reducing the pain of the patient surpass the occasional discomfort caused by leakage of the exudate and the maceration of the wound. Aquacel[®] Ag, on the other site, having the outstanding features of both occlusive and semi-occlusive dressings and relatively free from the fore mentioned disadvantages, seem to be closest to ideal dressing material for the management of the STSG donor site. Albeit, this material is currently so expensive that it is impossible to suggest it as the dressing of choice. The authors of this trial prefer Comfeel[®] Plus Transparent as the dressing of choice after these findings.

Conflict of interest statement

All of the authors state that they have no financial and personal relationship with any of the companies mentioned in the text.

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