Long-term Scar Quality after Treatment of Standardized Partial-Thickness Skin Graft Donor Sites

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ABSTRACT

BACKGROUND: The long-term aesthetic appearance of scars is of great importance to patients. Biobrane (Smith and Nephew, Fort Worth, Texas), a biosynthetic skin dressing, is a successfully established dressing for the treatment of superficial wounds. A new silk barrier dressing (Dressilk; Prevor, Moulin de Verville, France) has also shown good results in wound healing. This study evaluated the long-term scar quality of superficial wounds treated with these dressings.

METHODS: From February 2012 to May 2013, 11 patients with burns in need of skin grafting received donor site treatment. Study authors dressed 2 adjacent, standardized, partial-thickness skin graft donor sites on each participant with Biobrane or Dressilk. Scar formation on both treated areas was compared 24 months after initial application using subjective and objective assessment methods.

RESULTS: Independent of treatment, the majority of the patients described scar quality similar to normal skin using subjective and objective evaluation tools. However, for scar perfusion, significantly lower oxygen saturation was shown in both treated areas compared with untreated skin.

CONCLUSIONS: Comparatively, the 2 wound dressings showed similar results, making silk dressings an interesting alternative to biosynthetic ones.

KEYWORDS: biosynthetic dressing, fibroin, hemoglobin, long-term scar evaluation, nylon mesh, partial-thickness skin grafts, silk dressing, standardized donor sites, superficial wounds

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INTRODUCTION

After almost 20 years of observations in sociology research, both Beuf[1] and Thompson et al[2] showed that physical attractiveness is of central interest in our social environment. Rumsey et al[3] found nearly half of all patients with deforming conditions were clearly limited in terms of social integration and quality of life. The long-term aesthetic appearance of scars is therefore of great importance to patients.[4] After launching a study of 34 individuals with a wide range of scar types to assess behavioral coping patterns, Brown et al[5] found the majority of those studied were unhappy with their scar's appearance because of perceived stigma and psychological associations. Patients therefore tended to be unsociable and restricted in their communication skills, personal relationships, and work and private lives.[5]

Partial-thickness skin graft donor sites are superficial wounds, which are characterized by a standardized depth of injury, extending into the epidermis and the papillary dermis. These wounds are known for their prolonged healing duration and might even result in scar formation. Therefore, this kind of wound is the ideal model for comparing superficial wound healing and scar formation within an experimental clinical study design.[6]

Wound dressings have a direct impact on proliferation of keratinocytes.[7] They can influence both healing time and wound closure,[4,8,9] both of which are proportional to scar formation and cosmetic outcome.[10] In a previous prospective, randomized clinical trial study, authors compared 3 wound dressings: biosynthetic (Biobrane; Smith and Nephew, Fort Worth, Texas), silk (Dressilk; Prevor, Moulin de Verville, France), and cloth (PolyMem; Ferris Manufacturing Corporation, Fort Worth, Texas). Outcomes assessed in 28 participants' split-thickness skin grafting donor sites included pain, transparency of the dressing, active bleeding, exudate, inflammation, and cost efficiency. Both the biosynthetic and silk dressings offered comparably easy handling, continuous monitoring of the healing process, and a high level of patient comfort and mobility during the acute healing process.[11] Because of these positive qualities and despite high treatment costs, Biobrane biosynthetic dressing is currently the preferred treatment of superficial burn wounds—especially in hands and faces—in the authors' burn unit.

However, because the silk dressing showed good results,[11] the study authors wanted to evaluate whether it can deliver similar results and quality in the treatment of superficial burn wounds. For safety

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reasons, before evaluating Dressilk for the treatment of burn wounds, an investigation of long-term scarring after treatment of standardized superficial wounds with silk barrier dressings in comparison with biosynthetic dressings needed to be conducted.

METHODS

The following study was reviewed and approved by the Ethical Review Committee of the University of Witten/Herdecke, Germany. Complete informed consent was obtained from all patients.

Participants

From February 2012 to May 2013, 11 patients with burns in need of skin grafting received donor site treatment with Biobrane and Dressilk. Of the 15 patients assessed for eligibility, 4 declined to take part in the follow–up examination and were therefore excluded from the study. Exclusion criteria were a lack of consent and compliance to participate in the follow-up examinations and acute instability.

Intervention

Study authors dressed 2 adjacent, standardized, partial-thickness skin graft donor sites on each participant with Biobrane or Dressilk. Both wound dressings were applied as 5 × 5-cm dressings after a 0.2-mm partial-thickness skin graft harvest was conducted on the lateral thigh of each patient (Figure 1). Scar formation of both treated areas and untreated skin was compared 24 months after initial application with respect to (*a*) melanin and erythema level, (*b*) skin elasticity, (*c*) transepidermal water loss (TEWL), (*d*) scar perfusion, (*e*) the Patient and Observer Scar Assessment Scale (POSAS), and (*f*) the Vancouver Scar Scale (VSS). All scars were documented with standardized digital photography.

Measurements

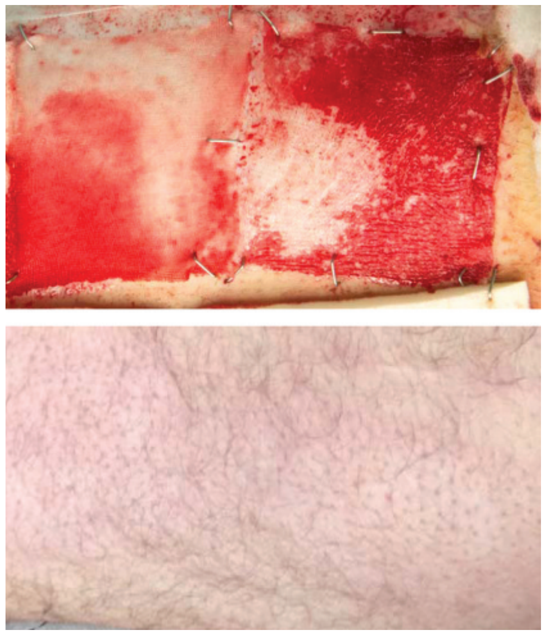
All follow–up examinations were performed in the same assessment room in a standardized manner. First, patients were asked to remain physically inactive for at least 20 minutes. Treatment areas were identified on the basis of the digital photographs taken postintervention. First, the quality of each scar was evaluated using POSAS and VSS. Thereafter, to minimize the interobserver error, all measurements were taken by the same experienced user. Probes were held perpendicular to the skin while minimal pressure was applied to avoid skin or scar blanching. All measurements were performed 3 times. Between measurements, the probes were completely removed and repositioned.

MATERIALS

Biobrane consists of a nylon mesh covered by porcine type 1 collagen. After initial application, the dressing adheres temporarily until fibrin grows in and a new tissue matrix is regenerated. Handling of the product and daily wound treatment are simple, and complications are rarely reported.[12] In a previous study, study authors found Biobrane well suited for wound assessment and monitoring because it remains transparent during the entire healing process, and results demonstrated only rare, mild signs of wound bed infection at late stages of wound healing.[11] Many authors recommend Biobrane as the ideal dressing material for cutaneous wounds and partial-thickness skin graft donor sites.[13–22] However, it is expensive compared with other dressing materials for cutaneous wounds.[13,14,17,20,22,23]

Dressilk is composed of the natural and biocompatible protein fibroin produced by silkworms.[24] This natural material is robust, promotes wound healing, and prevents inflammation.[25] Once applied on the wound bed, the dressing adheres, dries, and peels off by itself when the re-epithelialization of the wound is complete. Safety studies rate this dressing safe with respect to acute dermal toxicity, irritation, and skin sensitization.[26,27]

Figure 1.
APPLICATION OF 2 DRESSINGS IN A STANDARDIZED PARTIAL-THICKNESS SKIN GRAFT DONOR SITE STUDY DESIGN



Top, acute treatment; bottom, scarring 24 months after surgery.

Subjective Evaluation Tools

Various tools are available for the evaluation of scars. The traditional VSS is a validated, subjective scale for scar assessment.[28–30] Pliability, height, vascularization, and scar pigmentation are evaluated using 4 different clinical findings.

The POSAS is one of the few scar assessment tools that includes both patient and physician evaluation. The observer scale evaluates scar vascularity, pigmentation, thickness, relief, pliability, and surface area. All items are scored on a scale ranging from 1 ("like normal skin") to 10 ("worst scar imaginable"). Simultaneously, patients evaluate their scars with respect to pain, itching, color, stiffness, thickness, and relief. These items are scored on a scale ranging from 1 ("no" or "as normal skin") to 10 ("yes," "very different"). This tool has proven to be feasible, effective, reliable, and valid in many studies.[31] It is therefore considered the most suitable scar assessment scale and gives a numeric impression of leading scar characteristics.[32–36]

Objective Evaluation Tools

Tools for the objective assessment of scar formation in partial-thickness donor sites are rare. The Mexameter, Tewameter, and Cutometer (Courage+Khazaka Electronic GmbH, Cologne, Germany) are commercial noninvasive, in vivo diagnostic devices that have been widely acclaimed in various research studies. Superficial oxygen saturation (SO_2), hemoglobin concentration, and blood flow measurements were evaluated by means of laser Doppler spectrometry with the Oxygen to See device (O2C; LEA Medizintechnik GmbH, Gießen, Germany). Evaluation of the normal skin on the contralateral side of the corresponding lesion was used every time as a control value.

Erythema and melanin. The Mexameter MX 18 measures 2 skin attributes: melanin and hemoglobin (erythema). Van der Wal et al[37] showed that the Mexameter can provide reliable color data on skin and scars with a single measurement. The principle of the measurement is based on simple absorption and reflection of light emitted by the skin.[38–43] Melanin and the severity of erythema in the skin are measured in a relative unit (arbitrary unit) ranging from 0 to 999. Higher values indicate a higher level of melanin deposition and erythema.[44,45]

Viscoelasticity and pliability. The Cutometer dual MPA 580 measures the elastic and viscoelastic properties of the skin.[18–20] Fong et al[46] assessed the accuracy of the Cutometer at 0.01 mm and emphasized that a comparison with untreated skin is necessary. The degree of elasticity of the skin is the maximum value of skin distortion caused by constant suction pressure (400 mbar) for 3 seconds by the Cutometer. Skin deformation can be measured by this optical system and produce an accurate reading within 0.10 mm. In this study, the following values were analyzed: (*a*) R0 = total deviation of the skin (the lower this value is, the higher the firmness of the skin), (*b*) R2 = gross elasticity (the ratio between maximum amplitude and ability of regression; the closer to 1 [100%] this figure is, the higher the skin's elasticity), and (*c*) F1 = elasticity ([R0 × relaxation time] / [maximum amplitude × time]; the closer to 0 this value is, the more elastic the skin).

Transepidermal water loss. Physiologic evaporation takes place on the skin as an important part of its normal metabolism. Recent literature has demonstrated a positive correlation between improved scar quality and early physiologic recovery of barrier function.[47] Once the barrier function of the skin is damaged, TEWL increases. The Tewameter 580 is widely used in cosmetic and medical research to measure dermal sublimation of water. It consists of 2 pairs of sensors (temperature and relative humidity) in a hollow open cylinder without any influence of the microclimate of the skin surface. The TEWL is quantified by skin surface water loss in g/m^2.[42,48–50]

Laser tissue oxygen saturation, hemoglobin level, and microcirculation. Laser Doppler spectroscopy is a reliable tool for noninvasive in vivo measurement of microcirculation performed by combining white light tissue photo spectroscopy (detection range, 450–850 nm; resolution, 1 nm) and laser Doppler examination (wavelength, 830 nm; power, <30 mW). Superficial SO_2, relative amount of hemoglobin (as a marker of venous filling), and blood flow are measured in real time by the O2C device.[31,51–53]

Statistical Analysis

Study authors used Microsoft Excel 2013 (Microsoft, Redmond, Washington) to manage data and design the charts. Prior analysis data were checked for completeness, and accuracy checks were conducted. The final analysis was performed with SPSS version 21 (IBM, Armonk, New York). The data were collected prospectively. All 3 paired samples were analyzed for statistically significant differences first using the Friedman test. In case of significant differences, study authors used the Wilcoxon test for pairwise comparisons. Statistical significance was considered $P < .05$. Box plots were created to provide an overview of raw data regarding each evaluation technique.

RESULTS

A total of 11 patients (3 female and 8 male patients) aged 23 to 77 years (mean, 51 years) were enrolled in the study at an average of 29 months after surgery (minimum 24 months, maximum 37 months).

Results of Subjective Scar Evaluation

All patients reported a general subjective enhancement in the quality of both scars after treatment. All patients stated high satisfaction with scar quality. There were no statistically significant differences between VSS and POSAS scores for scars treated with either intervention.

Using the VSS, the average pigmentation of scars was assessed as normal (equal to untreated skin) or hypopigmented for both dressings. No scar was found to be hyperpigmented after treatment. Vascularity and pliability were mostly evaluated normal. The majority of scars were found to be of normal height (Table 1).

Table 1.

VANCOUVER SCAR SCALE: MEAN VALUES WITH EACH DRESSING

	Biobrane (n = 11)	Dressilk (n = 11)
Pigmentation		
0, Normal color	6	6
1, Hypopigmentation	5	5
2, Hyperpigmentation	0	0
Vascularity		
0, Normal	9	9
1, Pink	2	2
2, Red	0	0
3, Purple	0	0
Pliability		
0, Normal	9	9
1, Supple	2	2
2, Yielding	0	0
3, Firm	0	0
4, Banding	0	0
5, Contracture	0	0
Height		
0, Normal flat	9	9
1, <2	2	2
2, >2 and <5	0	0
3, >5	0	0

Observer evaluation following POSAS revealed similar results regarding scar quality for both dressings. All criteria evaluated including vascularity, pigmentation, thickness, relief, pliability, and scar surface area were similar to normal skin (Figure 2). Patients also could not significantly differentiate overall scar appearance (P = .317). For the majority of the patients, scars were not itching or painful. More than half of the patients described their scar as similar to normal skin. Further, more than three-quarters of the patients described scar structure (independent of treatment) as similar to normal skin (Figure 3).

Results of Objective Scar Evaluation

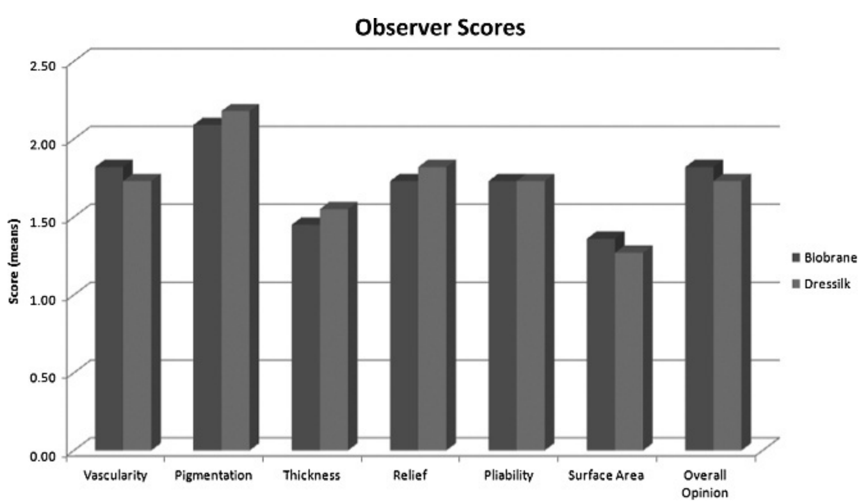
Objective assessment results from the Mexameter, Tewameter, Cutometer, and O2C devices of scars after Dressilk treatment, scars after Biobrane treatment, and untreated skin were initially compared to determine statistically significant differences with the Friedman test. Significant differences were found only in scar perfusion (SO_2; P = .012) and the Wilcoxon rank test for paired data was performed.

Data clearly showed a lower SO_2 in both treated areas compared with untreated skin (Biobrane: mean SO_2, 44.27 vs untreated skin: mean SO_2, 53.64 [P = .023]; Dressilk: mean SO_2, 42.91 vs untreated skin: mean SO_2, 53.64 [P = .05]). Therefore, untreated skin had significantly better SO_2 than scar tissue in this study, which can be explained by the reduced blood flow often found in scar tissue. Further results in hemoglobin level and microcirculation were similar for all 3 areas (Table 2, Figure 4).

Finally, no significant differences were found for viscoelasticity and pliability, melanin or erythema levels, or TEWL between the treated areas and untreated skin (Figures 5–7 and Table 3). Therefore, scars and untreated skin were virtually the same in terms of elasticity, perfusion, color, and fluid loss.

Figure 2.

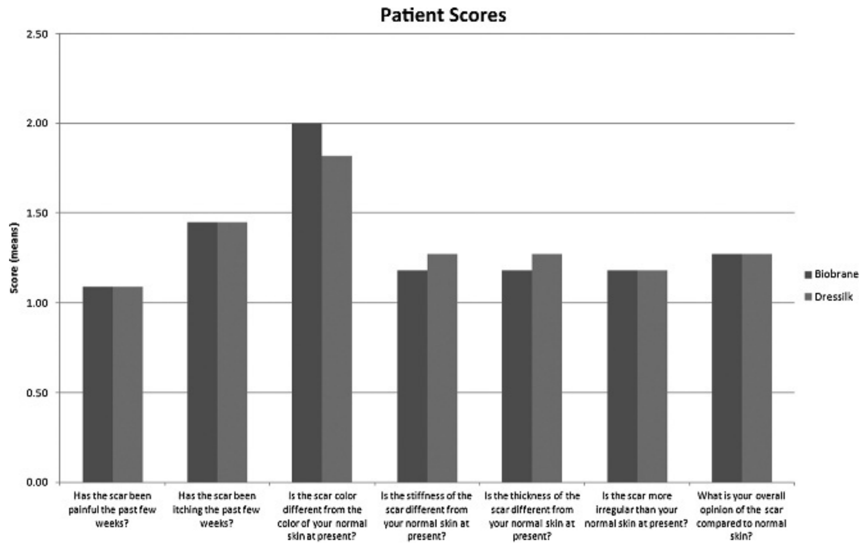
POSAS OBSERVER SCORES: SIMILAR RESULTS FOR BOTH DRESSINGS SLIGHTLY CLOSE TO NORMAL SKIN



Abbreviation: POSAS, Patient and Observer Scar Assessment Scale.

Figure 3.

POSAS PATIENT SCORES: SIMILAR RESULTS FOR BOTH DRESSINGS SLIGHTLY CLOSE TO NORMAL SKIN



Abbreviation: POSAS, Patient and Observer Scar Assessment Scale.

Treatment Costs

Prices for Biobrane and Dressilk vary depending on individual contracts between the facility and retail company. In case of the study authors' burn center, the price of Biobrane is approximately 10 times higher than Dressilk (per 1 cm^2).

DISCUSSION

Little information is available in the literature on follow-up scar evaluation with a focus on these specific dressings. So far, no study has been performed comparing these dressings directly regarding long-term scar formation.

The whole process of macroscopic scar remodeling takes approximately 6 months. Further, functional and physiologic healing of the injured skin and restoration of the cutaneous barrier takes much longer than epithelialization.[4,47] Nevertheless, the end point of wound healing is complex and difficult to quantify.[47] Keeping this in mind and to ensure stable scar formation, long-term scarring was examined after at least 24 months, and study authors compared scars within each single subject.

Outer appearance and the recovery of a functional skin barrier are governed in particular by the color mismatch between scar and normal skin, TEWL, and scar pliability.[4,6,46] For long-term

Table 2.

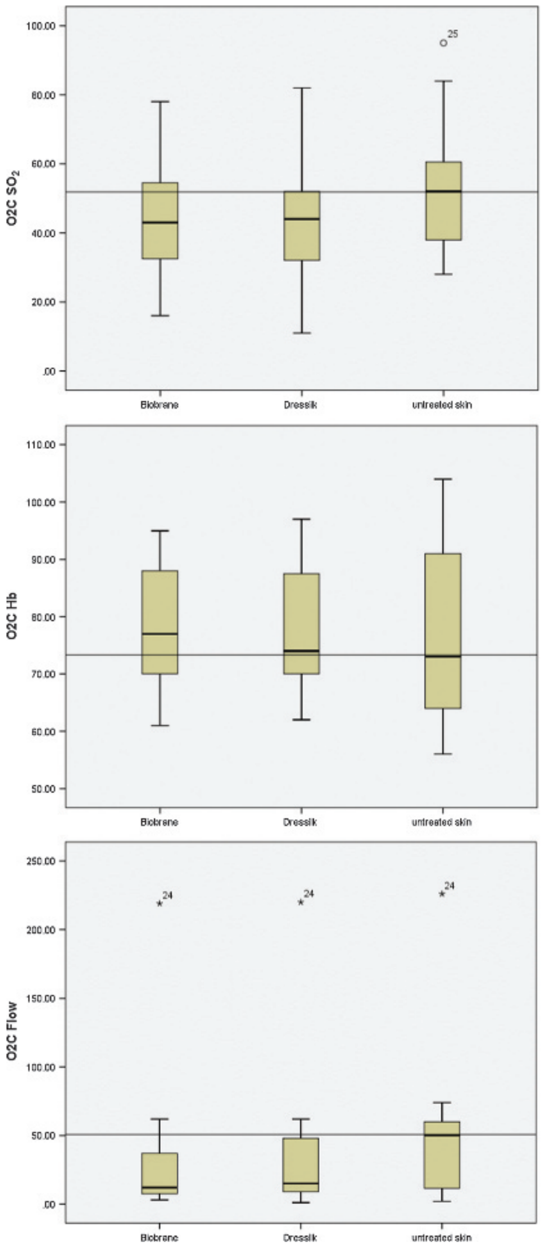
ADDING UP FOR ALL PATIENTS: MEAN VALUE, MEDIAN, AND SD FOR BOTH TREATMENT AREAS AND UNTREATED SKIN

		Biobrane			Dressilk			Untreated Skin		
		Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
Mexameter	Melanin	139.60	137.00	64.54	156.59	148.50	80.23	183.09	146.00	105.12
	Erythema	232.70	197.50	99.79	221.09	209.00	83.56	212.32	168.00	92.50
Cutometer	R0	1.17	1.21	0.37	1.31	1.25	0.31	1.33	1.34	0.29
	R2	0.84	0.91	0.15	0.90	0.89	0.11	0.88	0.95	0.16
	F1	0.17	0.14	0.08	0.19	0.13	0.18	0.17	0.16	0.07
Tewameter	TEWL	17.10	16.00	7.70	19.41	21.00	7.14	19.77	22.00	7.72
O2C	SO_2	44.27	43.00	18.56	42.91	44.00	18.56	53.64	52.00	21.30
	rHb	78.09	77.00	11.42	78.09	74.00	12.68	77.27	73.00	16.64
	Flow	38.82	12.00	62.54	43.82	15.00	62.21	53.09	50.00	62.69

Abbreviations: rHB, hemoglobin concentration; SO_2, oxygen saturation; SD, standard deviation; TEWL, transepidermal water loss.

Figure 4.

RESULTS OF O2C SCAR EVALUATION BASED ON RAW DATA: OXYGEN SATURATION (TOP), HEMOGLOBIN LEVEL (MIDDLE), AND MICROCIRCULATION (BOTTOM) WITH EACH DRESSING AND UNTREATED SKIN



scar assessment, scar contour, texture, and distortion are known to be most important.[45,54] Color mismatch between scar tissue and normal skin is based on scar pigmentation or scar redness and consists mainly of erythema and melanin.[45,54] Danielsen et al[55] found that pigmentation first increased during the first 3 months after surgery because of an increasing density of melanocytes. Over time, many scars develop hyperpigmentation, although the reason for this change is not well understood. Bond et al[56] found that hyperpigmentation develops after 12 months. In contrast to these findings, Velangi and Rees[57] showed that the number of melanocytes and melanogenic activity of long-standing pale scars were similar to normal skin. These results indicated no significant difference between the 2 dressings after objective scar assessment for color, as mentioned previously.

Erythema is the only significant component in long-term postoperative appearance of partial-thickness skin graft donor sites.[4] In this study, a fading of most scars approximately 7 months after wounding was described on the basis of clinical photographs. This study found no statistically significant difference in either subjective or objective scar assessment for erythema.

Figure 5.

RESULTS OF MEXAMETER SCAR EVALUATION BASED ON RAW DATA: SCAR MELANIN (TOP) AND ERYTHEMA (BOTTOM) WITH EACH DRESSING AND UNTREATED SKIN

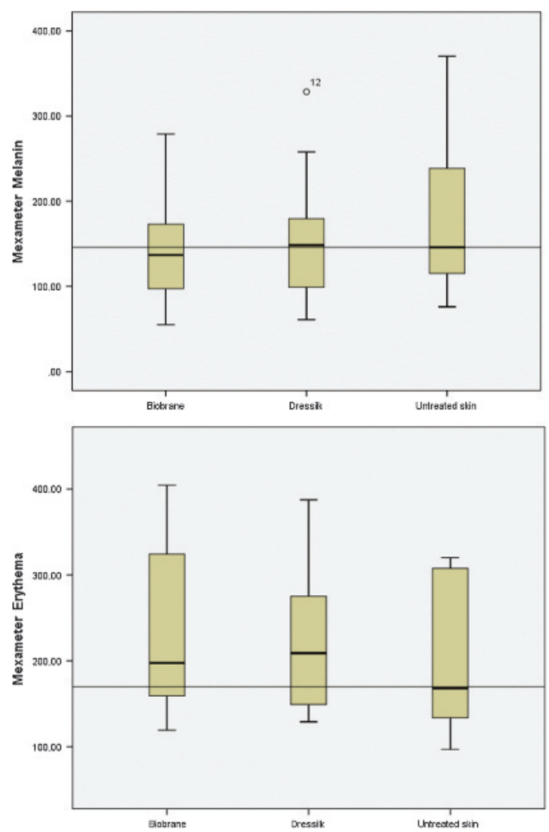
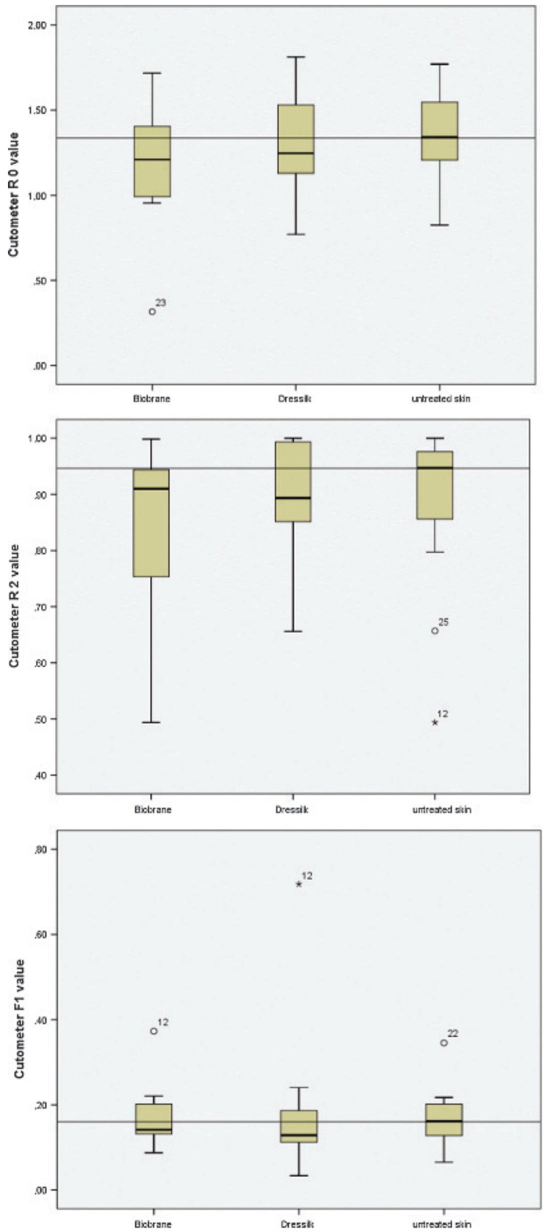


Figure 6.

RESULTS OF CUTOMETER SCAR EVALUATION BASED ON RAW DATA: SCAR ELASTICITY AND PLIABILITY FOR EACH DRESSING AND UNTREATED SKIN



Rennekampff et al[6] investigated Biobrane for scar pliability in a 6-month follow–up study. Although scars were assessed as equal to untreated skin following VSS, the Cutometer revealed a significant difference in total deformation, total recovery, immediate retraction, and immediate distension.[6] Rahmanian-Schwarz et al[16] came to the same conclusion comparing Biobrane and another wound dressing in superficial partial-thickness burn wound scars after 8 months. Biobrane was found to be superior in maximal extension, elasticity, retraction, and pliability—albeit without any statistical significance.[16] The results of this study coincide with these findings. Overall, both dressings lead to a good recovery of viscoelasticity and pliability similar to untreated skin.

Regarding the dermal sublimation of water, TEWL normalizes in solely epidermal wounds approximately 1 month after injury.[58,59] Especially in partial-thickness skin graft donor sites, previous studies found no significant differences in the evaluation of scar tissue and untreated skin for TEWL after a period of 6.5 to 13 months.[4,60,61] This corresponds with the findings in this study.

Interestingly, in this study, SO_2 was found to be significantly lower in scars compared with untreated skin after treatment with

Figure 7.

RESULTS OF TEWAMETER SCAR EVALUATION BASED ON RAW DATA: SCAR TRANSEPIDERMAL WATER LOSS WITH EACH DRESSING AND UNTREATED SKIN

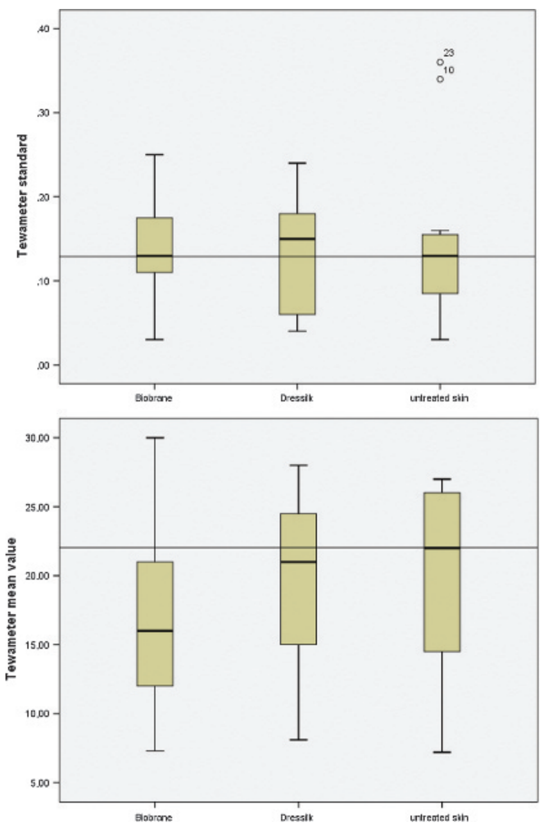


Table 3.

COMPARISON OF VISCOELASTICITY AND PLIABILITY, MELANIN OR ERYTHEMA LEVELS, TRANSEPIDERMAL WATER LOSS, AND MICROCIRCULATION: OVERALL P VALUE BASED ON FRIEDMAN TEST FOR 3 GROUPS AND PAIRWISE COMPARISON BASED ON WILCOXON RANK SUM TEST FOR PAIRED DATA

	Overall *P*	Biobrane/Dressilk	Biobrane/Untreated Skin	Dressilk/Untreated Skin
Mexameter melanin	.148	—	—	—
Mexameter erythema	.441	—	—	—
O2C SO_2	.012	1.000	.023	.05
O2C rHb	.441	—	—	—
O2C flow	.234	—	—	—
Tewameter SSWL	.976	—	—	—
Tewameter mean	.099	—	—	—
Cutometer R0	.513	—	—	—
Cutometer R2	.223	—	—	—
Cutometer F1	.909	—	—	—

Abbreviations: rHB, hemoglobin concentration; SO_2, oxygen saturation; SSWL, skin surface water loss.

either dressing. It is known that physiologic regulation of cutaneous microvascular function is a complex process governed by numerous factors such as environmental temperature, emotional state of the patient, and autonomic nerve function.[62] This was the reasoning for examining patients in a supine position after a quiet waiting period of 20 minutes in a noise-free room, as suggested by Heu et al.[63] This led study authors to observe significantly lower SO_2 for both scar areas compared with untreated skin.

Finally, treatment costs play a central role in providers' choice of dressing in their clinical routine. It should be noted that Dressilk is the more economical dressing compared with Biobrane, which may lead providers to favor it within their practice moving forward.

CONCLUSIONS

In this study, scars after Dressilk or Biobrane treatment were similar to untreated skin. Both dressings appeared to produce similar results, after examining subjective and objective factors. Based on the experience of the healing and scar formation in this study's superficial wounds, and given that Dressilk is a more financially attractive option than Biobrane, it might be an interesting alternative material for the treatment of superficial burns and should be evaluated for such use in further studies.

Limitations

This study has an important limitation regarding the limited sample size. Despite this, the evaluation of this small group delivered interesting findings on the potential use of both dressings. Study authors are currently searching for alternative solutions in superficial burn wound treatment to react independently when presented with wound dressing market changes. Based on the results presented in this study, scar quality should be evaluated in a larger study population in further research to prove significant statistical differences more precisely. A future study will compare both dressings in superficial burns with a larger number of participants.

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