OUR INITIAL EXPERIENCE IN THE CUSTOMIZED TREATMENT OF DONOR SITE AND BURN WOUNDS WITH A NEW NANOFIBROUS TEMPORARY EPIDERMAL LAYER

DÉBUT D'EXPÉRIENCE AVEC UN TRAITEMENT SUR-MESURE DU SITE DONNEUR ET DE BRÛLURES AVEC UNE COUCHE ÉPIDERMIQUE TEMPORAIRE NANOFIBREUSE

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SUMMARY. Recently, electrospinning technology has gained increasing attention for wound care. SpinCare™ electrospun polymer nanofibrous temporary epidermal layer is one of the latest developments in the market. Our objective was to explore the potential use of the new SpinCare™ system for treating burns and wounds. We conducted a single-center prospective observational trial, treating 10 patients with superficial to partial thickness wounds including burn wounds with a nanofibrous dressing. Treatment was evaluated, including procedures, place of injury, treatment times, ease of use etc. Ten superficial to deep dermal wounds were treated successfully. Inexperienced users learned the handling of the device quickly. Covering difficult-to-access wound surfaces was challenging. One leading problem is that the product is nearly opaque once applied on the moist wound. We introduced a standardized 3-day treatment protocol. After application, wounds were covered with a silicon layer for 2 days. The nanofibrous dressing appeared to be suitable following enzymatic debridement in burn wounds. Because there is a risk of wounds drying out under the dressing, the application should probably be limited to superficial and partial thickness wounds if not combined with other treatment options. The electrospun polymer nanofibrous temporary epidermal layer shows promising results in the treatment of superficial to partial thickness wounds including burns. However, minor improvements might help to optimize its usage and thus take full advantage of all existing treatment options.

Keywords: customized, antimicrobial, nanofibrous dressing, electrospun polymer, superficial wounds, burn wounds, aesthetic and functional outcome

RÉSUMÉ. *Récemment, la technologie d'électro filage, plus couramment appelée électro spinning, a trouvé des applications dans le domaine du traitement des plaies. SpinCare™, épiderme temporaire en polymères nano fibreux obtenu par électro spinning, est l'un des derniers développements sur le marché. Notre objectif était d'étudier les utilisations potentielles du nouveau dispositif SpinCare™ dans le traitement des brûlures et des plaies. Nous avons conduit une étude prospective, observationnelle, mono centrique. Nous avons traité 10 patients présentant des plaies de profondeur superficielle à intermédiaire, incluant les brûlures, avec le polymère nano fibreux. Nous avons évalué ce traitement, en tenant compte à la fois du protocole, de la localisation de la plaie, de la durée du traitement, de la facilité d'utilisation, etc. Nous avons obtenu la cicatrisation de 10 plaies atteignant le derme plus ou moins profondément. La courbe d'apprentissage était rapide. L'application sur des plaies de localisation difficile a pu être réalisée. L'un des problèmes majeurs est que le produit devient pratiquement opaque après application sur la plaie humide. Nous avons élaboré un protocole de traitement sur 3 jours. Après l'application du polymère nano fibreux, celui-ci a été recouvert d'une feuille de silicone pour 2 jours. Ce pansement semble pouvoir être appliqué sur une plaie ayant subi un débridement enzymatique dans le cadre des brûlures. En raison du risque d'assèchement de la plaie sous le pansement, son utilisation est probablement réservée aux plaies de profondeur superficielle à intermédiaire s'il n'est pas associé à d'autres options thérapeutiques. Cet épiderme temporaire en polymères nano fibreux obtenu par électro spinning semble être prometteur dans le traitement des plaies de profondeur superficielle à intermédiaire, y compris les brûlures. Cependant, quelques améliorations permettraient d'optimiser son utilisation et de supplanter avantageusement d'autres traitements.*

Mots-clés: *traitement sur-mesure, bactério statique, pansement nano fibreux, polymère électro tissé, plaie superficielle, brûlures, résultat esthétique et fonctionnel*

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Introduction

Even today, the treatment of burn wounds is challenging. The large number of dressings for superficial to partial thickness wounds currently available on the market is confusing. As shown in previous studies, the majority of superficial wounds including burn wounds might heal under various wound dressings in a timely manner, without complications and with good scar quality.[1,2] However, patients today are increasingly more demanding about modern wound treatment and often critically question the choice of burn wound dressings. Furthermore, in current literature it is often discussed how relevant less frequent and painless dressing changes are for the wellbeing of patients. Modern burn wound dressings try to take this idea into consideration.[3-6] Today many materials are light and thin and some of them peel off spontaneously, when re-epithelialization is complete.[2,7,8] However, medical staff still have to cut dressings to trim them to the exact size of the wound surface. Many dressings have to be fixed on the burn wound either by staples, by tissue glue or by an external dressing.[1,2] Each of these techniques causes additional pain during the procedure. Furthermore, for many dressings at least one dressing change or material removal is necessary in the further course of the treatment. Altogether, this is an interesting starting point to improve the characteristics of dressing materials. The application of an ideal dressing should be pain free. The dressing would ideally be individually customized to the wound size, and easy to handle for patients and medical staff. Patients should be able to continue their normal activities without limitations until healing is completed. Infection should be prevented and wound fluid should be absorbed.[9,10]

Electrospinning technology has gained increasing attention in various fields of medicine, including wound care.[10-16] Recently, an electrospun polymer nanofibrous dressing (PND; SpinCare™, Nanomedic Technologies Ltd., Lod, Israel) was introduced in pre-market activities. Using a hand-held device, the fully customized PND can be applied on the wound surface. In an initial study, Haik et al. investigated the use the PND on split thickness donor sites in pigs and found excellent results.[9] To our knowledge, until today no clinical study has evaluated the impact of PND on human donor sites and burn wounds. We present our first clinical experience in the treatment of donor sites and superficial to partial thickness burn wounds using PND with special respect to wound management, pitfalls and patient satisfaction.

Materials and methods

This study was reviewed and approved by the Ethical Review Committee of the University of Witten Herdecke, Germany (protocol nr. 24/2018). All patients were willing to take part in the study and signed a consent form.

Patient selection

The first 10 patients with superficial burn wounds were treated with the PND. Inclusion criteria were as follows: (a) participants must be at least 18 years old, in good physical condition, both sexes, (b) wounds are superficial to partial thickness; burn wounds caused by hot water or flame, (c) patients signed a consent form for treatment with the PND and participation in the follow-up examinations. Exclusion criteria were listed as: (a) lack of consent and agreement to participate in the study and the required follow-up examinations, (b) pregnancy or nursing, (c) skin injuries caused by long-term therapy with cortisone.

On admission, burn depth was evaluated following standard clinical characteristics as described elsewhere.[5,17] Wound healing progress was observed from first application of the PND until complete wound closure (defined as less than 5% remaining defect). Pain during application was measured using a 10-point numeric rating scale (NRS). Dressing changes, healing progress, complications and adverse events were closely monitored and accurately documented.

The application of the customized nanofibrous temporary epidermal layer

The SpinCare™ system creates in real time a personalized skin-like electrospun polymer nanofibrous dressing, which fits any individual wound size and can be applied on every body contour.

In the current study a standard of care was introduced for wound care after the PND application. The PND was applied only on clean wounds that showed no signs of infection. By using the SpinCare™ handheld electrospinning device a sterile biocompatible polymer solution is applied from a distance of approximately 20 cm, without coming in direct contact with the wound (*Fig. 1*). The right distance is guaranteed by a laser indication system. Thus, a nanofibrous temporary epidermal layer is created that covers the wound surface and the surrounding tissue (*Fig. 2*). The temporary epidermal layer adheres to the wound surface and is opaque after application. The dressing becomes transparent as soon as it comes into contact with fluids. It does not have to be replaced in the course of the wound healing process. In the current study, all wounds were covered with a thin silicone layer and dry gauze after the PND was applied. The silicon layer and the gauze were removed on the second day after PND application (*Figs. 2 and 3*). Afterwards patients were allowed to shower the wound without manipulating. When re-epithelialization was completed, the temporary epidermal layer peeled off spontaneously.[9]

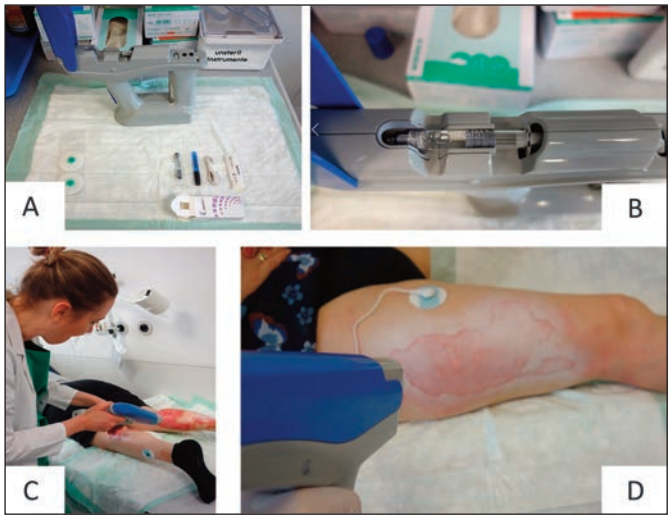

Fig. 1 - PND application: (A) handheld and accessories needed for treatment; (B) the sterile cartridge is placed into the handheld; (C, D) PND is applied on the wound surface at the correct distance with the help of a laser pointer.

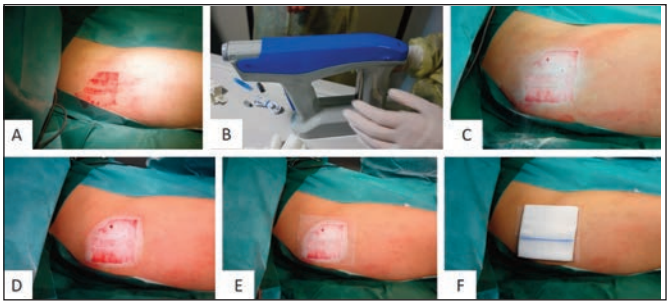

Fig. 2 - Representative split thickness donor site at the lateral upper leg treated with PND: (A) split thickness donor site before dressing; (B) device for application; (C) after application of PND; (D) after removal of PND from the dry surrounding skin; (E) covering the PND with a silicon layer; (F) second layer of cotton gauze.

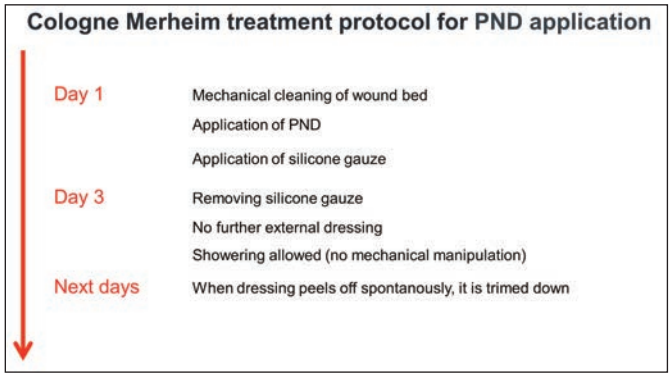

Fig. 3 - The PND application: timeline of treatment procedure

Enzymatic debridement

When the burn depth was evaluated as partial thickness to deep dermal at admission, wound debridement was performed by enzymatic debridement. In the current study, a partially purified proteolytic protein mixture derived from pineapple plant stems was used (NexoBrid®, Mediwound, Israel). Thus, burn eschar was selectively dissolved while vital and healthy tissue could be preserved.[18-21] In the current study, enzymatic debridement was performed following a three-day treatment procedure comprising a prolonged pre- and post- soaking time overnight (*Fig. 4*). Debridement was performed under local / regional anesthesia and analgosedation

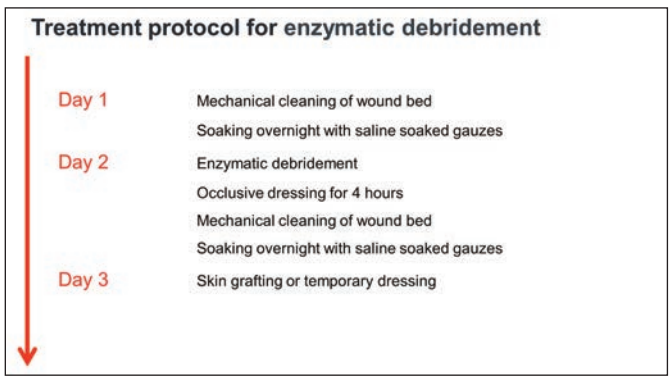

Fig. 4 - Enzymatic debridement: timeline of treatment procedure.

following overnight soaking on the second day after burn injury.[22] Afterwards, further wound treatment has to be performed according to the wound depth. In the case of full thickness wounds, the wound has to be covered by a skin transplant.[22-24] In the current study, superficial to partial thickness burn wounds were temporarily covered with the PND.

Results

Between November 2017 and March 2018, 10 superficial to partial thickness wounds, including 4 split thickness donor sites and 6 burn wounds, were treated with the PND. Patient age ranged between 19 and 76 years (mean 54 years, STD 15.93). Four female and 6 male patients were treated. The mean total wound surface area was 3% (min 1%, max 4.5%, STD 1.38%). In the current study between 0.25% and 2.5% of this area was treated with the PND (mean 1.27%, STD 0.71).

Within the first 10 treatments, we found that the handling of the device and the application of the temporary epidermal layer was easy to learn for medical staff (*Fig. 1*). The PND was applied between the day of injury and up to 21 days post injury. No adverse events and no signs of infection were found in any of the cases we treated. Healing time ranged between 9 days and 30 days for all wounds (*Table I*).

Table I - Ten patients treated with superficial to partial thickness wounds including burns with the PND

Age	Kind of wound	Surface	Wound depth	Wound area	Enzymatic debridement	Period between accident and dressing	Pain NRS (0-10)	Wound healing (days)
19	Donor site	0.5%	Superficial	Upper leg	No	1 day	General anesthesia	11
76	Donor site	1.5%	Superficial	Upper leg	No	1 day	General anesthesia	12
44	Donor site	1%	Superficial	Upper leg	No	1 day	General anesthesia	12
52	Donor site	1%	Superficial	Upper leg	No	1 day	General anesthesia	14
74	Burn	2.5%	Superficial - partial thickness	Face	Yes	2 days	1(10)	9
55	Burn	1%	Superficial - deep dermal	Dorsum hand	Yes	21 days	1(10)	30
57	Burn	0.25%	Superficial	Dorsum hand	No	1 day	1(10)	15
47	Scald	2%	Superficial	Lower leg	No	10 days	1(10)	16
56	Scald	2%	Superficial	Lower leg	No	10 days	1(10)	16
57	Burn	1%	Partial thickness	Dorsum hand	Yes	14 days	1(10)	28

Split-thickness donor sites

Skin harvesting was performed under general anesthesia in 4 patients. For the first two wounds we did not use any secondary dressing after applying the PND. These wounds were located at the dorsal and at the lateral upper leg. However, in these wounds we found an excessive exudation from the wound surface directly after the application of the PND. Patients and nurses complained that the exudation soiled the sheets. Furthermore, by movement in the bed, one temporary epidermal-layer at the lateral leg got lost partially and the wound had to be covered by a different second ibuprofen-containing foam dressing. For that reason, we had to repeat the PND application. This time, the second temporary epidermal layer peeled off spontaneously without any complications after re-epithelialization was completed. Both wounds healed in less than 14 days.

Based on the experiences associated with excessive exudation, we defined a standardized treatment after the PND application for the following treatments. Wounds were covered after PND application with a silicone layer and dry gauze (*Fig. 2*). The silicon layer and the gauze were removed on day 3 (second day after the PND application, *Fig. 3*). Afterwards patients were allowed to shower regularly without manipulating the wound area. In both cases, the temporary epidermal layers were found to adhere nicely to the wound surface and peeled off spontaneously after re-epithelialization was completed within 14 days.

Superficial to partial thickness burns

The next 6 wounds, which were treated with the PND, were superficial to partial thickness burns and hyper granulating tissue (2 scalds and 4 burns caused by flame) located on the face, on the lower leg and on the dorsum of the hand (*Table I*).

The first patient was admitted with a superficial to partial thickness facial burn, caused accidently as the patient smoked while receiving oxygen via a nasal cannula. The burn wound was debrided enzymatically under local anesthesia. The PND was applied on the 2nd day after admission under oral pain medication under anesthesia with metamizole and intravenous application of piritramide. The patient reported minimal pain (NRS 1/10). After application of the PND, the wound was covered with a silicon layer, gauze and an external head bandage (*Fig. 5*). A few hours after the treatment, the patient removed the external dressing himself. Nevertheless, the PND remained stable on the wound surface. Wound healing proceeded without any complications.

The 2nd burn wound was located on the dorsum of the left hand. Initially, enzymatic debridement

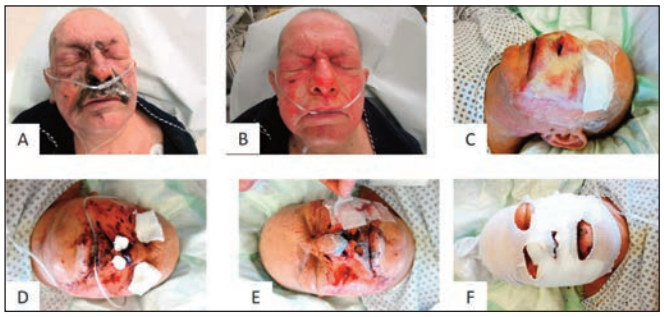

Fig. 5 - Representative patient with mixed dermal facial burn treated with a PND: (A) facial burn at arrival; (B) burn wound after mechanical cleaning; (C) application of enzymatic debridement; (D) preparation of wound for application of PND; (E) after application of the PND, covering the PND with a silicon layer; (F) second layer of cotton gauze and external head bandage.

was performed. Burn depth was found to be partial thickness to deep dermal after enzymatic debridement. After enzymatic debridement, the wound was initially treated with a combination of a moist cellulose based dressing and platelet rich fibrin. After 21 days the wound regime was changed. Most of the wound surface was already healed. Small remaining defects and areas of hyper-granulation were treated by cortisone ointment as described elsewhere. Afterwards, the PND was applied.[5] Complete healing in these areas could be achieved after another 9 days (*Fig. 6 A, B and C*).

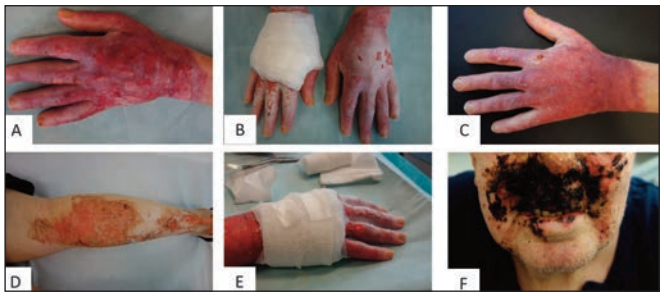

Fig. 6 - Representative patient with partial thickness to deep dermal burn of the dorsum of the left hand treated with enzymatic debridement and application of PND in the later stages of the treatment: (A) burn wound after enzymatic debridement and a period of 21 days spontaneous healing; (B) wound after application of the PND; (C) healing completed at day 30; (D) scald of the dorsal lower leg treated with the PND at day 10 after injury; (E) PND extends like a spider´s web over the fingers, hardly adhering at the interdigital space; (F) PND soaked with wound exudate and secondary bleeding in a patient under anticoagulation therapy without any external dressing.

The 3rd patient was admitted to hospital due to a superficial burn wound on the dorsum of the right hand caused by flame burn. The wound was cleaned mechanically. When the PND was applied under oral pain medication with metamizole (*Fig. 7 A and B*), the patient reported only minimal pain (NRS 1/10). After the external silicon dressing had been removed after the second day, the wound was showered without manipulation. It adhered well to the wound surface (*Fig. 7 C*). In the further course of the healing process, the temporary PND wound dressing became stiff and brown (*Fig. 7 D*). It finally peeled off spontaneously after re-epithelialization was completed (day 15). Hand function was excellent after 3 and 12 months (*Fig. 7 E and F*).

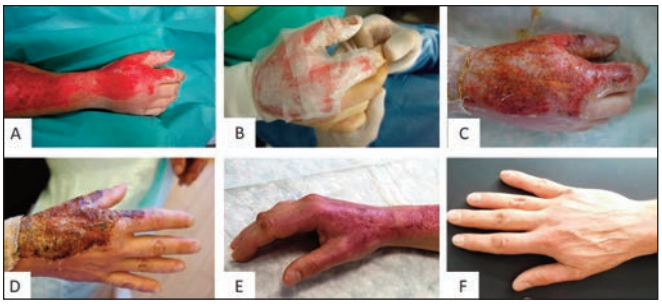

Fig. 7 - Representative patient with superficial burn of the dorsum of the right hand treated with PND: (A) burn wound after mechanical cleaning; (B) wound after application of the PND and a silicon layer; (C) typical pattern after removing the external dressing at the second day after treatment which indicates the remaining PND; (D) stiff and hard crust of exudate in further healing process; (E) healing completed and the PND peeled off spontaneously at day 15; (F) good scar quality 12 months after the treatment.

Three more wounds (one burn wound on the dorsum of the left hand and a scald wound on each lower leg) were treated by application of the PND successfully. The two wounds on the lower legs were superficial burned. They were covered with the PND on the 10th day after scald injury. The mean healing time was 16 days.

The wound on the dorsum of the hand was partial thickness burned. Thus, firstly enzymatic debridement was performed in order to dissolve the burn eschar. After debridement, Suprathel® (Polymedics Innovations GmbH, Denkendorf, Germany) was applied on the wound surface. In the further course of the wound healing, Suprathel® had to be removed due to wound bed infection.

After keeping the wound bed moist by daily dressing change with antiseptic solution, the wound finally became clean. At that point, the PND was applied. Final wound healing took another 14 days (*Table I*).

Discussion

In recent research, electrospun fibres were discovered to be useful in various fields of medicine. Considerable potential was found regarding surface-to-volume ratio, tissue engineering and drug delivery. Among other advantages, the structure of the dressing´s nanofibrous matrix enhances fibroblast adhesion and proliferation and therefore promotes wound healing.[25] For this reason, electrospun fibres appeared extremely suitable for dressings in dermal wounds.[13,26-28] In the recent past, various animal studies and clinical studies in humans revealed the potential of nanofibrous dressing materials in different settings with promising results.[25,27,29] One of the most recent developments in this field is SpinCare™ PND, a customized nanofibrous temporary epidermal layer that can be applied directly onto the wound surface by electro spun technology.[9]

Customized size of the temporary epidermal-layer

Today, a broad range of dressings is available on the market to cover superficial wounds with good results (foam dressings, silk dressings, nylon membrane, silicon membrane, hydrocolloid dressings and many more).[1,8,23,30,31] The majority of these dressings offer a high degree of patient comfort and some of them are even opaque.[7,23,30] In comparison to these dressings, the main advantage of the PND is that it can be adjusted to the individual wound size.[9] When the PND has been applied, it can be detached from the non-injured skin areas immediately. The dressing becomes transparent shortly after application. The wound does not need any additional dressing after the external dressing is removed on the third day. In sum, this dressing allows a maximum range of motion for physiotherapy and the use of extremities in everyday life (*Fig. 7D*).

Structure of the nanofibrous temporary epidermal-layer

It has been a point of discussion whether the PND offers the best structure for a superficial burn wound dressing or if superior structures exist. To answer this question, Haik et al. compared 4 different nanofibrous structures for PND in the development phase of the dressing in a porcine model on split thickness donor sites. They found no significant differences among the groups.[9] According to our first experiences, the structure of the PND is suitable to cover all wound types and to attach well on the wound surface over the entire wound healing period.

Learning curve and first experience

We found that handling of the device is easy to learn for medical staff. Only minor problems were encountered: the handheld had to be cleaned after every single use to prevent the nozzle on the device becoming clogged. The device is operated using a battery, which has to be charged at regular intervals. An electrode has to be fixed to the patient´s body to enhance an electromagnetic field before the PND can be applied on the wound surface.

However, during our first treatments, we identified some pitfalls in the application of the PND. Firstly, we found that the wound bed should be free of hair. Otherwise the finely woven layer spans like a spider´s web over the hair. In this case the dressing does not come into direct contact with the wound bed and cannot adhere to it. The same problem happened when we applied the PND onto the finger of a hand: like a spider´s web the layer extended over the fingers, hardly adhering to the interdigital space (*Fig. 6 E*). In order to achieve an optimal adherence in these areas, we asked our patients to extend their fingers as wide as possible when applying the PND. We expect the same problems when toes and ears should be covered with the PND.

Pain during treatment

In the current observational study, the application of a PND was found to be nearly pain-free and could be performed under oral pain medication with metamizole only. Patients with superficial burns reported that they even felt a pain reduction by the gentle cooling effect of the airflow during the application of the PND.

Adherence of the electrospun polymer nanofibrous dressing

The ideal nanofibrous layer should adhere stable to the wound surface while at the same time be resistant against shearing forces.[11,32] In accordance with Haik et al., we found that the dressing adheres

stable to the wound surface.[9] Even if the PND was applied on a moist wound surface, it adhered well. After application, the PND is covered with a silicon mesh and an external dressing for three days. When these layers have been removed, patients can return to everyday routine, are allowed to wear clothes and can move freely. We found that the PND even works for patients under anticoagulation therapy, suffering from secondary bleeding. We found efficient wound healing in a facial burn although the patient did not accept any additional external dressing after the PND application (*Fig. 6 F*).

Wound exudation

Haik et al. reported that wounds do not show heavy exudation under PND.[9] However, it has to be taken into consideration that their pig study was performed on the basis of donor sites only. Burns are known to cause relevant exudation in the first days.[5,17] We found that even heavy exudation might escape through the permeable mesh structure of the PND. Thus, wound healing is supported.[6] However, exudation accumulated in the PND over time and was found to be hard and stiff as soon as it became dry (*Fig. 6 D*). Some patients complained of both a feeling of tension and of restricted mobility of joints at this state. It is important to remember, however, that the same complaints occurred when other dressings were used for heavily exuding wounds.[3,23] We found that by applying a silicon mesh and an external dressing for three days, most of the wound fluid could be absorbed. Furthermore, the external dressing protects the wound and prevents direct contact with linen and clothes. This might be useful if the wound is heavily exuding and exposed to shear forces.

Transparency of the electrospun polymer nanofibrous dressing

When the PND is applied on the moist wound surface, it is quickly saturated with wound fluid and becomes completely transparent. Thus, wound assessment is easy at any time. On the other hand, it is hard to judge whether or not the wound surface is completely covered with the PND. This problem becomes particularly relevant if large surfaces have to be covered with the PND sufficiently (*Fig. 5 B*).

After removing the external dressing on the third day, it is difficult to see whether the thin and transparent PND remains on the wound surface or not. This causes some problems in handling the dressing correctly for early users. In order to solve this problem, we covered the PND with a silicon layer, which had a textured surface. Thus, we could notice the nearly invisible layer of the PND by the imprint of the silicon layer left on the PND (*Fig. 7 B and C*).

Wound bed infection

In accordance with reports in the literature, we did not find any sign of wound infection in any of the wounds treated with the PND.[10] The dressing was found to protect the wound against microbial penetration by its nanofibrous, multi-layer material and its nanoporosity.[9] Rieger et al. described that an antibacterial nanofibrous mat was found suitable to reduce biofilms in chronic wounds.[32] Biofilms play a central role in chronic wound healing.

Preem et al. even stated that the development of an antimicrobial bioactive wound dressing might be more important than removing the bacteria.[27] It could be shown that electrospun nanofibrous materials can be combined and soaked with both various antibacterial polypeptides, calcitriol and drugs and with wound healing enhancing pharmaceuticals.[10,11,15,16]

Thus, wound infection during healing can be prevented and healing is improved even in complicated chronic wounds.[11,12,29] We have followed this approach in our study. We cleaned the wound bed with Prontosan® (B. Braun, Melsung, Germany) a polyhexanide-based antiseptic wound rinsing solution, which was found suitable for treating complicated burn wounds.[22,33,34]

When the external dressing was removed on the third day, we soaked the PND with Prontosan®. However, in the case of any slight signs of infection, we recommend removing the PND from the wound surface.

Application of the electrospun polymer nanofibrous dressing after enzymatic debridement

There are many discussions among experts regarding which dressings are most suitable after enzymatic debridement of burn wounds. The first

superficial to partial thickness wounds following enzymatic debridement that we treated with PND presented good healing. For deep dermal wounds, a moist wound bed is needed to allow spontaneous wound healing.[4,5,22,34,35] This is also the case for deep dermal wounds following enzymatic debridement.[4,22,34] If the PND is applied on a deep dermal wound, the wound might become dry because of the permeable structure of the dressing. For that reason, we do not recommend using the PND on wounds that are deeper than partial thickness.

Only one burn wound in this study was deeply burned. The PND was applied to cover only hypergranulated remaining defects of this wound after a successful initial healing period of 21 days under a moist Suprathel® dressing. In one case of a partial thickness facial burn, we applied the PND on the wound surface directly after enzymatic debridement and found uncomplicated healing (*Table I*).

In sum, after enzymatic debridement the PND is a suitable dressing for superficial to partial thickness wounds.

Wound healing capacity and scar quality

Studies showed that the nanofibrous structure encourages cell proliferation and migration of keratinocytes. Thus, excellent conditions for wound healing and skin regeneration are provided. In rats, Liu et al. presented improved scarring by using electrospun nanofibrous dressings.[9,11,36] In humans, studies found good healing without scarring when different nanofibrous dressings where used for wound treatment.[9,10,25,29]

In our study we proofed the PND to be suitable for good wound healing without any complications in donor sites and superficial to partial thickness burn wounds. Long-term hand function after more than 6 months was excellent in all three patients that were treated with PND for hand burns.

One main advantage of the PND is that patients can start using their hand without any external dressing on the third day after PND application. For all wounds treated, we found good healing and excellent aesthetic and cosmetic outcome 12 months after the PND application without any complications (*Fig. 7 E*).

Treatment costs

Most nanofibrous dressings on the market are quite expensive.[37] However, we see a potential saving in treatment costs by using PND. The dressing only had to be applied once. In the further course of the wound healing, the dressing was removed on the third day without any additional dressing changes needed (*Fig. 3*).

However, the price of the product, which is not given yet, has to be taken into consideration.

Conclusion

In the current study we present our learning curve and first experiences with the SpinCare™ PND. We found that the PND is a patient friendly, customized temporary epidermal layer for the treatment of superficial to partial thickness wounds including burns. However, we found room for improvement if wound cavities have to be covered. Inexperienced users are advised to treat donor sites first.

These wounds are standardized and easy to handle. The handling of the device can be learnt quickly.

Limitations

The current observational study has several major limitations. On the one hand only 10 wounds were evaluated. Among them, both time of first treatment and pretreatment of the wounds differed. Nevertheless, we intended to present our initial learning curve and main pitfalls of the treatment.

We found that the treatment in general seems to be suitable for superficial to partial thickness burn wounds including wounds following enzymatic debridement. In addition, we presented a treatment algorithm over 3 days. In a next step, treatment of superficial to partial thickness burns with the PND has to be evaluated on a larger scale in a prospective clinical study design.

Special emphasis must be placed on healing time and long-term scarring. This study is currently being performed by our group and will be presented in the near future.

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