White Paper

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Scientific compendium: **SUPRA**THEL®, a versatile, fully synthetic, resorbable epidermal and dermal skin substitute

Learn more about **SUPRA**THEL®

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Herbert L. Haller*, Booker T. King**

Scientifically proven advantages when using Suprathel® are

reduced need for pain medication; reduction of the need for autografting (potentially due to reduced burn wound conversion rates); reduction in healing time; usability in situations when biologics are prohibited for ethical or religious reasons; reduced workload; amelioration of the inflammatory response and oxidative stress; and the wide range of indications for Use are described in scientific papers.

TECHNICAL DESCRIPTION

Suprathel® is a fully synthetic, absorbable, microporous alloplastic temporary skin substitute.

Regulatory aspects

Suprathel® has a shelf life at room temperature of three years.

Form and structure

The porous membrane has a **nearly symmetrical cross-section**, with interconnected pores varying in size between 2 and 50 µm. It is fully **degradable in a humid environment.**

Physical properties

It is elastic, pliable, and has a memory of form, is permeable to water, prevents fluid accumulation beneath the surface, maintaining a relatively moist wound environment.

It conforms to the shape of the wound bed at body temperature, is self-adherent to wounds, and typically does not require additional fixation with staples, sutures, or glue. The membrane structure provides an effect on tissue neogenesis and vascularization, and resorption.[1]

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Indications

Suprathel® is suitable for all ages, with additional advantages in pediatric patients. FDA certification is for Use in donor sites, superficial and partial thickness burns, partial thickness wounds with areas of full thickness, and abrasions and exfoliative skin diseases.[2] Suprathel® has shown benefits for wound coverage after enzymatic debridement, coverage from cell suspensions, usage over widely meshed grafts, and temporization of full thickness wounds before standard procedures.

Application

It has a form elasticity, so it should not be stretched during application.

It does require a secondary non-adherent dressing as a separation layer from the outermost absorbent dressing; Jelonet® and Silicon-based non-adherents such as Rylon® (See figure 1) may be used for this purpose.

Distribution

The product is well-accepted and widespread in Burn Centers in 39 countries worldwide, becoming a gold standard for partial thickness burns

in major European markets[3], the United States, and Latin America.

How does Suprathel® work?

Why it works

Suprathel® enables fibroblast ingrowth and angiogenesis. It does not elicit a foreign body reaction and provides a safe cover for the wound, enabling the healing process; as a mono-layered epidermal and dermal skin substitute, its qualities are comparable to human skin.

The wound-healing effects of Suprathel® have several underlying mechanisms described below.

The Barrier Effect

The barrier preventing infections

The design of Suprathel® can prevent bacterial translocation[4], as demonstrated (in vitro) with both Pseudomonas aeruginosa and Staphylococcus aureus.

The barrier preventing fluid loss

Together with a secondary dressing, Suprathel® and fibrin form a reduced-permeability layer, keeping the wound relatively humid inside but dry outside. Due to its semi permeability, Suprathel® allows some fluid to escape and not to cause retention. Suprathel® forms together with fibrin and cells a layer during the first days, reducing water vapor permeability over the next days to nearly zero. This layer reduces water and serum loss and makes the dressings drier and the wounds less prone to infection by microorganisms, reducing the need for frequent dressing changes with reduced wound care burden on patients and staff.

The barrier preventing energy loss

The Suprathel®, Fibrin, and cell layer reduces **evaporation fluid loss** and heat and energy loss and reduces hypermetabolism.[5,6]

The barrier providing Hemostatic properties

Kaartinen confirmed the ability to reduce blood loss and other wound secretions.[7] By this, the adherence of Suprathel® is improved.

Biochemical effects on wound healing

The biochemical effect is based on the **effects of Lactate as a signaling molecule.**

The literature suggests that Lactate is a valuable **energy source** and transporter and can function as a **free radical scavenger**. It activates local and systemic effects.[8–10] A „**Lactormon**“ Lactate directs cellular metabolism, angiogenesis, and growth and repair.[9] Ring et al. demonstrated an **increase in the vascularization** of wounds covered by Suprathel® via **stimulation of angiogenic factors** such as **Vascular Endothelial Growth Factor (VEGF).**[11] An **increase in the number of vessel sprouts, new interconnections in capillaries, demonstrated by functional vessel density expansion for 17% on days 10, and red blood cell velocity for 70%** was demonstrated by intravital fluorescence microscopy.[1] Lactate with oxygen **increased endothelial cell migration and stimulated matrix metalloproteinases, fibroblast migration and collagen synthesis, and extracellular matrix generation.**[11,12] Lactate **stimulates Transforming Growth Factor beta** (TGF-β) generation from precursors. This positive effect is necessary for early wound healing, but long-lasting high-level TGF-β causes myofibroblast generation.[13,14]

SYSTEMIC EFFECTS

Effects on oxidative stress

Reduction of pro-and an increase in anti-inflammatory cytokines

Suprathel® regulates inflammation by influencing pro-and anti-inflammatory cytokines.[14] It

significantly reduced pro-inflammatory IL-6 by 34% and 4% on days 7 and 14, respectively, and TNF-α levels by 44% and 89% on days 10 and 14.) compared to Hydrofiber Ag (HfAg) dressing.[15]

Reduction of Total Oxidant Capacity and an increase in Total Antioxidant Capacity:

This effect was demonstrated by comparing Total Oxidant Capacity (TOC) and Total Antioxidant Capacity (TAC). Suprathel® reduced TOC to low levels after three days to 16%, TAC on day seven was 3.3 times higher than HFAg levels.[16]

Effect on TGF-β

Suprathel® also increased anti-inflammatory TGF-β significantly from day 3 (+434%) to day 21 (+370%) compared to HfAg.[14]

Effect on length of telomeres

Oxidative stress decreases the length of telomeres[15] by reducing telomerase activity—treatment with Suprathel® increases the telomerase activity by 380% compared to SSD treated skin and 620 % to HFAg and increased the skin cell count by 205% compared to HFAg and 125% to SSD thought to improve the quality of healing skin.

EFFECTS ON REDUCING BURN WOUND CONVERSION

Burn wound conversion happens over the first few days after injury and results in the progression of wounds that could be treated conservatively to deeper wounds that require grafting to heal.

A prospective study showed that Suprathel® reduced systemic oxidative stress[16] and reduced inflammatory response, both critical contributors to burn wound conversion.

Two retrospective studies have shown a reduction in the need for grafting in Suprathel® versus standard of care (SOC), suggesting a reduction in burn wound conversion[18]. The reduction of grafting rate in partial thickness burns was from 27% (SOC) to 7%. Apoptosis also appears to contribute to burn wound progression via the upregulation of connexin.[17] Antiapoptotic measures, such as the downregulation of reducing connexin by the addition of poly-L-lactide (a component of Suprathel®), reduces apoptosis and heals wounds faster. All these components are reliable indicators for the positive effect of Suprathel® on burn wound conversion.[18]

Effect on systemic stabilization and fluid needs

Systemic physiologic stabilization after Suprathel® is an often-reported feature. Rubenbauer et al. described a case of epidermal necrolysis treated with mainly silver products. The patient rapidly deteriorated, developing fluid overload, hypokalemia, and the need for sedation and mechanical ventilation, within a day of Suprathel® application, the patient‘s critical condition rapidly reversed, allowing extubating.[19]

Effect on ionizing radiation injury

The effect of free radical scavengers on reducing ionizing radiation injury damage is well known. Lactate‘s radical binding activities include the attenuation of the post-inflammatory response, delay of cell division with more time for the repair, and enhanced DNA repair.[19]

Rothenberger first described the external application of radical scavenging Suprathel® for radiation injury. 40 Gy therapy for melanoma resulted in moist desquamation of the wound. After Suprathel® application, the wound healed within ten days. Radiation was continued up to 70 Gy without recurrence of dermatitis and decreased inflammation with immediate pain relief. Subsequent case reports describe the same findings.

Effect on pain and opiate reduction

Compared to Jelonet*, Mepilex®, and Omiderm® (ITG Laboratories, Redwood City, CA), pain reduction ranged between 30% and 63% and was statistically significant. This was confirmed in several studies in partial thickness burns, donor sites, radiation injury, and exfoliative skin diseases, demonstrating an impressive reduction of opioids.[20,21] Grigg et al.[20] demonstrated the opioid reduction, showing that 25% more patients could be discharged without opioids than in standard dressings. Everett et al.[22] showed that the average number of intravenous narcotic doses was 1.4 before and 0.1 after Suprathel® application. Fischer et al.[23] describe the reduced need for additional painkillers under Suprathel® treatment, impacting the course of treatment in a patient of high age and large TBSA positively, stabilizing him under treatment. Highton et al. described the elimination of opiates fur dressing changes under Suprathel® treatment.[24] Glat et al. describe the amount of pain medication given and after Suprathel® decreasing from 1.5 doses to 0.1 doses per patient.[25]

The reason for reduced pain might be the sufficient coverage of free nerve endings and the free radical scavenging properties of Suprathel®. The reduction of oxidative stress and pro-inflammatory cytokines may play a role as well.

It decreases sedation requirements during ventilation and dressing changes, decreases postoperative recovery time, early mobilization, and early functional improvement. The adverse effects of opioid Use are avoided, including dizziness, hypotension, constipation, loss of appetite, and edema because of fluid-creep and drug dependency. Suprathel® can facilitate outpatient care by making home dressing changes and wound care less painful.[25–27]

Effect on the reduction in workload

Suprathel® and the separation layer should stay in place until the wound has healed. The change of the external absorbent dressings is usually done on day three after application. Subsequent dressing changes for smaller burns are only necessary when the outer dressing is wet, stained, or foul-smelling. In more extensive burns, more frequent dressing changes may be required.

Compared to other treatment modalities, the number of dressing changes could be reduced to 1/10th to 1/3rd [28], with the time needed for dressing changes also reduced. No special preparation is necessary, and only the change of the external absorbent layer and a final compression layer is required, such as allowing self-care by the patient at home and fewer outpatient clinic visits.

WOUND COVERAGE OUTCOMES

Donor sites

Using Suprathel® for donor sites includes the advantages of reduced pain, reduced workload, and reduction in healing time. Reharvesting can be done earlier and repeatedly. Healing times range from 7 to 9 days in children[25,22] and from 7 to 14 days in adults.[26,29,30]

Partial thickness burns

Partial thickness burns are the main indication for Suprathel®. Treatment can be performed early, protecting wounds from superinfection, reducing the need for grafting. Cosmetic results are better compared to mesh graft with improved Patient and Observer Scar Scale (POSAS) values, Vancouver Scar Score (VSS), and patient scar scale after one and six months and better cosmesis.[2,31]

It helps to preserve donor areas for the usage of

full thickness areas or to avoid them altogether. Pain reduction in partial thickness burns is significant compared to other modalities[7,28], as well, as it showed a shorter healing time than SOC (topical cream, silver product). It has a low infection rate in partial thickness burns of approximately 2.4%.[30]

Use in mixed and full thickness burns

Areas that are partial thickness will heal spontaneously within 14 to 21 days. Suprathel® will not become adherent in full thickness areas, thus indicating the need for grafting within 7-10 days. The advantage of this method is that the overall need for autografting is reduced, the patient stabilizes physiologically, and the risk of infections is low.

In austere conditions, Suprathel® can be used as a temporary cover with the delayed removal of necrotic tissue after several days, according to the guidelines. All the uses described above support in the management of indeterminate burns without neglecting burn wound progression.[32]

Suprathel® can be used in full thickness burns after complete excision as a temporary cover, reducing pain and workload when the situation does not allow definitive autografting. Several burn centers have adopted Suprathel® for this indication to replace cadaveric homograft (personal communication).

Use in Burn-like Syndromes

Suprathel® in Exfoliative Skin Diseases

Since in 2008, Pfurtscheller described ST in this indication, multiple studies describe Toxic Epidermal Necrolysis (TEN) patients' treatment with Suprathel® superior to allograft.[33,34] Several case reports describing the Use of Suprathel® in treating Staphylococcal scaled skin syndrome[35], phototoxic plant burns[36], frostbite[37], epidermolysis bullosa) aplasia cutis. Suprathel® showed fast healing without complications in Toxic Epidermal Necrolysis (TEN) or Steven Johnson's Syndrome (SJS) compared to allograft®. It has a reduced systemic inflammatory response compared to silver dressings.[16,30]

Use after enzymatic debridement

ST reduces the need for dressing changes as requested by the European Consensus on Enzymatic Debridement (E. D.) 2017[38], and it was declared as „useful" in the update of the consensus.[39] A Spanish consensus recommended Suprathel® as the most appropriate dressing after E.D. A prolonged after soaking eight hours is suggested due to increased effusions after E.D.

Suprathel® had a shorter healing time overall, especially in extensive burns with a higher modified Baux Score.[40] The shorter healing time and pain reduction, and fewer dressing changes are the main arguments for the Use of Suprathel® after E.D.

Use as a cover for sprayed keratinocytes or in a Sandwich Technique

Suprathel® was used successfully as a cover after spraying cultured and non-cultured keratinocytes on partial thickness wounds. Results indicate a better and faster healing time compared to other treatment modalities.[41] It is also used successfully in a sandwich technique on expanded mesh grafts or Meek procedures.[42]

HOW TO USE SUPRATHEL®

- **When to apply Suprathel®**

  The Use of Suprathel® is **suggested early** after injury. Early debridement may support the

inhibition of burn wound progression by Suprathel®. The method of debridement may support your evaluation of wound depth.

- **Disinfection and removal of necrotic tissue**
  In the standard Use, Suprathel® is applied after disinfection and complete necrosis removal by debridement, dermabrasion, tangential excision, or other methods.
  After removing necrotic tissue, check the wound ground for viable tissue, as this will direct your further procedures. Debridement should be done to **punctuate bleeding** of the wound ground, indicating nearly complete necrosis removal. The application of **epinephrine-soaked pads** can help to achieve hemostasis.

- **Evaluate the chance of healing**
  Superficial partial thickness burns can be treated with Suprathel® without requiring further surgical procedures.
  Deep partial thickness burns can be treated with Suprathel® if there are sufficient remnants of regenerative epidermal tissue or hair follicles. The less regenerative tissue is available, the longer healing time can be expected, and the worse the quality of the healed skin will be. So, it is suggested to do autografting when the healing time expected is longer than 21 days.
  Small areas of full thickness burns can be treated conservatively if their size is smaller than a coin.
  The healing time to be expected is between three and six weeks, so consider grafting after three weeks.

- **Application of Suprathel®**
  Suprathel® should be applied without stretching it, overlapping the membranes by 1-2 cm if several membranes are needed to cover the wound. It should also overlap the wound's margin by three to four centimeters to avoid exposure to the wound during motion, causing pain and disturbance. In very recent wounds, especially in toddlers, there will be significant effusion, needing good prevention of Suprathel® swimming off. This usually is done by adequate dressing and compression, sometimes by sutures removed at the first dressing change.

- **Application of a Separation Layer**
  Suprathel® must be covered entirely with a separation layer (usually fatty gauze or Rylon®) to avoid adhering to external absorbent dressing and involuntary removal during dressing changes. Therefore, the separation layer must overlap the wound sufficiently (at least one hand's width) in fatty gauze, or so that removal is hindered by the adherence of the separation layer to normal skin (Rylon®). Two layers of fatty gauze should be sufficient.

- **Application of the absorbent layer**
  An absorbent layer is applied over the separation layer, usually consisting of a multilayer absorbent cotton, ideally from the roll. A zig-zag procedure should avoid the stricture of the extremity.

- **Application of external compression**
  External compression by elastic bandages or a crepe bandage should be done to stabilize the dressing, which can be fixed by adhesive tapes when the patient is moving. **Compression is a crucial step** as it hinders the fluid accumulation and the dislocation of the dressing during movement.

- **Dressing changes**

  Dressing changes are only done down to the separation layer to ensure Suprathel® is not lifted off the wound. Changes of absorbent and compression layers are recommended on day three or four, **done with care not to remove the separation layer** and the Suprathel® underneath. In smaller wounds, no further dressing changes are needed except for hygienic reasons. In more extensive wounds, additional dressing changes are suggested. Discoloration, wet or foul smell is an indication for a dressing change.

- **Removal of dressings and check for healing**

  Healing can be expected earliest after 7 – 10 days. Control is done by the removal of the external dressing and free-floating parts of the separation layer.

  When the wound is healed, **Suprathel® can be detached easily and trimmed together with the adherent separation layer.**

  Adherent parts should not be removed force fully, wait for two or three days, and repeat the procedure.

  Sometimes the restrained Use of (antibiotic) cream can be of help. It causes fewer problems to leave the dressing in place than to have an unhealed wound.

- **Crucial Topics to take care of:**

  - **Dressing changes**, be careful not to remove the separation layer and Suprathel®
  - Apply sufficient **compression** to avoid troubles!
  - Do not stretch the Suprathel®
  - When using more sheets to cover the wound, make a one-centimeter overlap.
  - Take care that Suprathel® overlaps the margins of the wounds for at least one finger's width.
  - Suprathel®

SCIENTIFIC BACKGROUND IN NUMBERS

Studies on Suprathel®

Up to Dec. 2020, sixty-six journal-published studies on Suprathel® are available for the public. Fifteen of them were designed as prospective studies with ten prospectively randomized, and six were in animals—additionally, ninety-five congress contributions orally or as posters were presented. There are lots of planned and ongoing studies.

Studies on healing time

Thirteen studies gave information on healing time. In partial thickness burns, the healing time was retrieved from six studies with an accurate description with 12.64 days on average from 367 patients. The healing time to be expected in donor areas is 5.7 days[43] to 14 days.[7] When comparing healing times of different products, similar healing times were found[44–46] with Jelonet®, Omiderm®, Biobrane, and Mepilex®, but Gürünlüoglu found a significantly shorter healing time compared to Hydrofiber Ag[16], Blome Eberwein found a shorter healing time compared to Transcyte® and Biobrane®.[47] Lindford found a shorter healing time of Suprathel® compared to allograft.[34]

Studies on pain

A positive impact of Suprathel® on pain was shown in 22 studies. Eight of these studies were prospective ones. Suprathel® was compared to standard of care, Jelonet® Mepilex®, Mepilex Ag®, Mepilex transfer®, Biatain Ibu®, Omiderm®, and allografts. The reduction of pain when using Suprathel® was between 63%[34] and 30%.[28] Four

studies describe a relevant opiate reduction.

Studies on infections

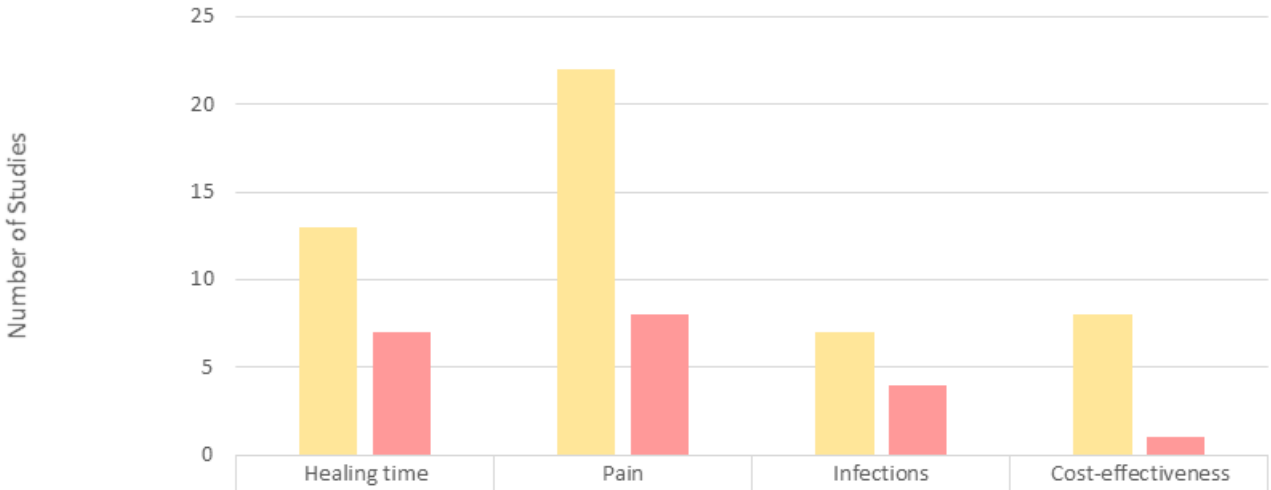
From the studies of Blome Eberwein et al.[48], Everett et al.[27], Hundeshagen et al.[26], Iqbal et al.[49], Rashaan et al.[50], and Schwarze et al.[44], an infection rate of 0.5% could be derived in pediatric patients and 6.6% from adults.

Across all published studies with valid data on this topic, the infection rate from 373 patients was 2.9%, which can be considered relatively low.

Studies describing cost-effectiveness

When describing costs, it must be evaluated differently for material costs and total treatment costs. Eight studies describe the cost-effectiveness of Suprathel®.

Lower total costs were described in detail by Schwarze et al.[44], Everett et al.[27], Fischer et al.[51] and Glat et al.[25]



LITERATURE

1. Ring A, Tilkorn D, Ottomann C, Geomelas M, Steinstraesser L, Langer S, et al. Intravital monitoring of microcirculatory and angiogenic response to lactocapromer terpolymer matrix in a wound model. Int Wound J 2011;8:112–7. https://doi.org/10.1111/j.1742-481X.2010.00742.x.
2. Keck M, Selig HF, Lumenta DB, Kamolz LP, Mittlböck M, Frey M. The use of Suprathel(®) in deep dermal burns: first results of a prospective study. Burns 2012;38:388–95. https://doi.org/10.1016/j.burns.2011.09.026.
3. Uhlig C, Rapp M, Hartmann B, Hierlemann H, Planck H, Dittel K-KK. Suprathel®-An innovative, resorbable skin substitute for the treatment of burn victims. Burns 2007;33:221–9. https://doi.org/10.1016/j.burns.2006.04.024.
4. Haller H, Held-Föhn E. Investigation of Germ Patency of a Polylactic Acid-based Membrane for the Treatment of Burns, Abstract. J Burn Care Res 2020;41:S173–S173. https://doi.org/10.1093/jbcr/iraa024.273.
5. Kaartinen IS, Kuokkanen HO. Suprathel(®) causes less bleeding and scarring than Mepilex(®) Transfer in the treatment of donor sites of split-thickness skin grafts. J Plast Surg Hand Surg 2011;45:200–3. https://doi.org/10.3109/2000656X.2011.583515.
6. Caldwell FT, Wallace BH, Cone JB, Manuel L. Control of the hypermetabolic response to burn injury using environmental factors. Ann Surg 1992;215:485–90; discussion 490-1.
7. Kaartinen IS, Kuokkanen HO. Suprathel® causes less bleeding and scarring than Mepilex® transfer in the treatment of donor sites of split-thickness skin grafts. J Plast Surg Hand Surg 2011;45:200–

3. https://doi.org/10.3109/2000656X.2011.583515.
8. Gladden LB. Lactate metabolism: a new paradigm for the third millennium. J Physiol 2004;558:5–30. https://doi.org/10.1113/jphysiol.2003.058701.
9. Philp A, Macdonald AL, Watt PW. Lactate--a signal coordinating cell and systemic function. J Exp Biol 2005;208:4561–75. https://doi.org/10.1242/jeb.01961.
10. Groussard C, Morel I, Chevanne M, Monnier M, Cillard J, Delamarche A. Free radical scavenging and antioxidant effects of lactate ion: an in vitro study. J Appl Physiol 2000;89:169–75. https://doi.org/10.1152/jappl.2000.89.1.169.
11. Constant JS, Feng JJ, Zabel DD, Yuan H, Suh DY, Scheuenstuhl H, et al. Lactate elicits vascular endothelial growth factor from macrophages: A possible alternative to hypoxia. Wound Repair Regen 2000;8:353–60. https://doi.org/10.1046/j.1524-475X.2000.00353.x.
12. Pinney E, Liu K, Sheeman B, Mansbridge J. Human three-dimensional fibroblast cultures express angiogenic activity. J Cell Physiol 2000;183:74–82. https://doi.org/10.1002/(SICI)1097-4652(200004)183:1<74::AID-JCP9>3.0.CO;2-G.
13. Beckert S, Farrahi F, Aslam RS, Scheuenstuhl H, Königsrainer A, Hussain MZ, et al. Lactate stimulates endothelial cell migration. Wound Repair Regen 2006;14:321–4. https://doi.org/10.1111/j.1743-6109.2006.00127.x.
14. Mehmet DEMİRCAN, M.D., and Kubilay GÜRÜN LÜOĞLU M. The IL6 , TNF- α, and TGF- β Levels in Serum in Children with Treated by Different Burn Dressings Searching of the ideal burn wound dressing continues …. JBCR 2019;40:354.
15. Demircan M, Gurunluoglu K. 354 The IL-6, TNF-alpha, and TGF-ß Levels in Serum and Tissue in Children with Treated by Different Burn Dressings. J Burn Care Res Abstr 2019;40:S154–S154. https://doi.org/10.1093/jbcr/irz013.264.
16. Gürünlüoğlu K, Demircan M, Taşçi A, Üremiş MM, Türköz Y, Bağ HG, et al. The effects of two different burn dressings on serum oxidative stress indicators in children with partial burn. J Burn Care Res 2019;40:444–50. https://doi.org/10.1080/13632469.2017.1342302.
17. Feng J, Thangaveloo M, Siang Y, Jack S, Joethy J, Becker DL. Connexin 43 upregulation in burns promotes burn conversion through spread of apoptotic death signals. Burns 2020. https://doi.org/10.1016/j.burns.2020.03.011.
18. Spitz DR, Hauer-Jensen M. Ionizing Radiation-Induced Responses: Where Free Radical Chemistry Meets Redox Biology and Medicine. Antioxid Redox Signal n.d.;20:1407–9. https://doi.org/10.1089/ars.2013.5769.
19. Rubenbauer J. Erfolgreiche Behandlung eines Lyellpatienten mit Suprathel. GMS Verbrennungsmedizin 2018:1–2. https://doi.org/10.3205/18dav54.
20. Grigg M, Clenwen T, Jason B. Donor site dressings: how much do they affect pain? ANZBA 2018. https://www.mendeley.com/reference-manager/reader/8ea85f41-059c-3096-ab92-ee76df2b04e4/1e556e1f-5932-1173-6f10-287641fb2542/ (accessed May 15, 2020).
21. Stoicea N, Costa A, Periel L, Uribe A, Weaver T, Bergese SD. Current perspectives on the opioid crisis in the US healthcare system: A comprehensive literature review. Medicine (Baltimore) 2019;98:e15425. https://doi.org/10.1097/MD.0000000000015425.
22. Everett M, Massand S, Davis W, Burkey B, Glat PM. Use of a copolymer dressing on superficial and partial-thickness burns in a paediatric population. J Wound Care 2015;24:S4–8. https://doi.org/10.12968/jowc.2015.24.Sup7.S4.
23. Fischer S, Kremer T, Horter J, Schaefer A, Ziegler B, Kneser U, et al. Suprathel(®) for severe burns in the elderly: Case report and review of the literature. Burns 2016;42:e86–92. https://doi.org/10.1016/j.burns.2016.05.002.
24. Highton L, Wallace C, Shah M. Use of Suprathel® for partial thickness burns in children. Burns 2012;39:2–7. https://doi.org/10.1016/j.burns.2012.05.005.
25. P.M. Glat, Burkey B, Davis W. The use of Suprathel® in the treatment of pediatric burns: Retrospective review of first pilot trial in a burn unit in the United States. J Burn Care Res 2014;35:S159.
26. Hundeshagen G, Collins VN, Wurzer P, Sherman W, Voigt CD, Cambiaso-Daniel J, et al. A prospective, randomized, controlled trial comparing the outpatient treatment of pediatric and adult partial-thickness burns with suprathel or Mepilex Ag. J Burn Care Res 2018;39:261–7. https://doi.org/10.1097/BCR.0000000000000584.
27. Everett M, Massand S, Davis W, Burkey B, Glat PMM, M. E, et al. Use of a copolymer dressing on superficial and partial-thickness burns in a paediatric population. J Wound Care 2015;24:S4–8. https://doi.org/10.12968/jowc.2015.24.Sup7.S4.
28. Markl P, Prantl L, Schreml S, Babilas P, Landthaler M, Schwarze H. Management of split-thickness donor sites with synthetic wound dressings: results of a comparative clinical study. Ann Plast Surg 2010;65:490–6.

https://doi.org/10.1097/SAP.0b013e3181d37624.
29. Schiefer JL, Rahmanian-Schwarz A, Schaller H-E, Manoli T. A novel hand-shaped suprathel simplifies the treatment of partial-thickness burns. Adv Skin Wound Care 2014;27:513–6. https://doi.org/10.1097/01.ASW.0000455692.04617.35.
30. Blome-Eberwein SAA, Amani H, Lozano DDD, Gogal C, Boorse D, Pagella P, et al. A bio-degradable synthetic membrane to treat superficial and deep second degree burn wounds in adults and children – 4-year experience. Burns 2020:2–10. https://doi.org/10.1016/j.burns.2020.08.008.
31. Selig HF. Suprathel versus autologous split-thickness skin in deep-partial-thickness burns. Burns 2011;37:S19. https://doi.org/https://doi.org/10.1016/S0305-4179(11)70076-6.
32. Cancio LC, Barillo DJ, Kearns RD, Holmes JH, Conlon KM, Matherly AF, et al. Guidelines for Burn Care under Austere Conditions: Surgical and Nonsurgical Wound Management. J Burn Care Res 2017;38:203–14. https://doi.org/10.1097/BCR.0000000000000368.
33. Pfurtscheller K, Zobel G, Roedl S TM, Abstract M. Einmalige Anwendung von Suprathel Toxisch Epidermaler Nekrolyse (TEN) bei einem Säugling mit. Gms/ 25 Jahrestagung Der Deutschsprachigen Arbeitsgemeinschaft Für Verbrennungbehandlung 2007.
34. Lindford AJ, Kaartinen IS, Virolainen S, Vuola J. Comparison of Suprathel ® and allograft skin in the treatment of a severe case of toxic epidermal necrolysis. Burns 2011;37:6–11. https://doi.org/10.1016/j.burns.2011.07.015.
35. Mueller E, Haim M, Petnehazy T, Acham-Roschitz B, Trop M. An innovative local treatment for staphylococcal scalded skin syndrome. Eur J Clin Microbiol Infect Dis 2010;29:893–7. https://doi.org/10.1007/s10096-010-0927-x.
36. Rapp M, Al-Shukur FF, Junghardt K, Liener U. Kontaktverbrennung durch Pflanzen. MMW-Fortschritte Der Medizin 2017;159:42–6. https://doi.org/10.1007/s15006-017-9846-4.
37. Mądry R, Struzyna J, Stachura-kułach A, Drozdz Ł, Bugaj M, Mądry R, et al. Effectiveness of Suprathel® application in partial thickness burns, frostbites and Lyell syndrome treatment. Pol Prz Chir Polish J Surg 2011;83:541–8. https://doi.org/10.2478/v10035-011-0086-5.
38. Hirche C, Citterio A, Hoeksema H, Koller J, Lehner M, Martinez JR, et al. Eschar removal by bromelain based enzymatic debridement (Nexobrid®) in burns: An European consensus. Burns 2017;43:1640–53. https://doi.org/10.1016/j.burns.2017.07.025.
39. Hirche C, Citterio A, Hoeksema H, Koller J, Lehner M, Martinez JR, et al. Eschar removal by bromelain based enzymatic debridement (Nexobrid®) in burns: An European consensus guideleines update PREPRINT. Burns 2020;43:1640–53. https://doi.org/10.1016/j.burns.2017.07.025.
40. Sander F, Haller H, Hartmann B. Factors Influencing Healing Time After Enzymatic Debridement. J Burn Care Res 2020;41:S193–4. https://doi.org/10.1093/jbcr/iraa024.308.
41. Hartmann B, Haller HL. Use of Polylactic Membranes as Dressing for Sprayed Keratinocytes- Retrospective Review Over103 Cases. J Burn Care Res 2019;40:S224–S224. https://doi.org/10.1093/jbcr/irz013.389.
42. M.Rapp, R. Schappacher UL. Zweizeitige Deckung von Spalthaut-Meek-Inseln nach 7- 10 Tagen mit einer Polylactid-Membran (Suprathel). In: Society GM, editor. DAV 2020, 2020.
43. Demidova O, Manushin S. Alloplastic skin substitute (SUPRATHEL®) dressings in treatment of donor sites in children with burns. Moressier 2019 2019:2017. https://doi.org/https://doi.org/10.26226/morressier.594bbebfd462b8028d893e61.
44. Schwarze H, Küntscher M, Uhlig C, Hierlemann H, Prantl L, Ottomann C, et al. Suprathel, a new skin substitute, in the management of partial-thickness burn wounds: Results of a clinical study. Ann Plast Surg 2008;60:181–5. https://doi.org/10.1097/SAP.0b013e318056bbf6.
45. Uhlig C, Rapp M, Dittel KK. Neue Strategien zur Behandlung thermisch geschädigter Hände unter Berücksichtigung des Epithelersatzes Suprathel®. Handchirurgie Mikrochirurgie Plast Chir 2007;39:314–9. https://doi.org/10.1055/s-2007-965234.
46. Rahmanian-Schwarz A, Beiderwieden A, Willkomm L-MM, Amr A, Schaller H-EE, Lotter O. A clinical evaluation of Biobrane® and Suprathel® in acute burns and reconstructive surgery. Burns 2011;37:1343–8. https://doi.org/https://doi.org/10.1016/j.burns.2011.07.010.
47. Blome-Eberwein SA, Amani H, Lozano D, Gogal C. 501 Second-Degree Burn Care with a Lactic Acid Based Biodegradable Skin Substitute in 229 Pediatric and Adult Patients. J. Burn Care Res., vol. 39, 2018, p. S223–S223. https://doi.org/10.1093/jbcr/iry006.423.
48. Blome-Eberwein SA, Amani H, Lozano DD, Gogal C, Boorse D, Pagella P. A bio-degradable synthetic membrane to treat superficial and deep second degree burn wounds in adults and children – 4 year experience. Burns 2020. https://doi.org/10.1016/j.burns.

2020.08.008.
49. Iqbal T, Ali U, Iqbal Z, Fatima ZJ. Role of Suprathel® in Dermal Burns in Children. JSM Burn Trauma 2017;2:2–5.
50. Rashaan ZM, Krijnen P, Allema JH, Vloemans AF, Schipper IB, Breederveld RS. Usability and effectiveness of Suprathel® in partial thickness burns in children. Eur J Trauma Emerg Surg Off Publ Eur Trauma Soc 2017;43:549–56. https://doi.org/10.1007/s00068-016-0708-z.
51. Fischer S, Kremer T, Horter J, Schaefer A, Ziegler B, Kneser U, et al. Suprathel® for severe burns in the elderly: Case report and review of the literature. Burns 2016;42:e86–92.https://doi.org/10.1016/j.burns.2016.05.002.