# ALDEHYDE-TREATED PORCINE SKIN VERSUS BIOBRANE AS BIOSYNTHETIC SKIN SUBSTITUTES FOR EXCISED BURN WOUNDS: CASE SERIES AND REVIEW OF THE LITERATURE

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**SUMMARY**. *Background*. The use of skin substitutes as temporary or permanent coverings has been a subject of research and study since 1500 BC. Temporary coverage of the burn wound can decrease the metabolic rate, fluid loss, pain, and colonization. The aim of this study is to review clinical experience with Biobrane and aldehyde-treated porcine skin (E.Z. Derm) as biosynthetic skin substitutes for the treatment of excised burn wounds. *Methods*. Fifty-two patients (42 males and 10 females) with deep dermal and full-thickness burns were selected for this retrospective study. Half of these patients were treated with Biobrane (this part of the study covered the period Jan. 1995/Dec. 1999) and the other half were treated with E.Z. Derm (Jan. 2000/Dec. 2005). The mean total body surface area (TBSA) burned was 30%. The excisional therapy was carried out in stages, each procedure being limited to 7-15% TBSA. All the patients underwent either tangential excision or excision down to the muscle fascia. The male/female ratio was 3:1 and the patients' ages ranged between 5 and 67 yr (mean, 35 yr). Data collection included: initial observation (age, sex extent of burn, depth of burn, photograph), skin substitute observation (adherence, presence of fluid collection, rejection, infection, photograph), and follow-up wound evaluation. *Results*. Both Biobrane and E.Z. Derm reduced pain, decreased evaporative water and heat loss, and limited bacterial growth. Both decreased exudative protein loss, protected the underlying vessels and nerves, and enhanced the healing of partial-thickness wounds. Both promoted the development of granulation tissues to be ready for autografting, and neither presented antigenicity or transmitted diseases. Porcine skin showed limited wound adhesion and limited control of infection compared to Biobrane. *Conclusion*. Biobrane and E.Z. Derm protected excised burn wounds from bacterial contamination and dehydration. It can be concluded that Biobrane has the potential for long-term adherence (10 days). Aldehyde-treated porcine skin (E.Z. Derm) is a reliable tool for short-term use and should not remain on the wound more than 3-4 days.

## Introduction

Burn injury threatens life by two major mechanisms: first, the loss of body fluids, protein, and electrolytes through the damaged skin and, second, infection of the necrotic burned skin, which is a good medium for bacteria to induce sepsis. Surgical excision of the eschar requires immediate coverage. Some areas can be covered with autograft. However, when the burn injury is extensive and autograft is not available, temporary wound coverage becomes mandatory. A temporary covering allows time for subsequent closure with skin autograft. An allograft is a reliable biological temporary skin substitute, with the disadvantage of its antigenicity, availability, and disease transmission.[1] Amnion is readily available and inexpensive. It promotes rapid epithelial ingrowth in full-thickness burns.[2] Fresh-frozen porcine xenograft has proved to be an effective temporary biological skin substitute. It adheres well to the wound and, when removed, a clean granulating wound remains.[3] Collagen has been used in many forms as a biological substitute. These forms include dermal collagen allograft[4] and, more recently, Integra.[5] Collagen has a hydrophilic surface for cell adhesion and mobility and stimulates a highly vascularized granulating wound.

A variety of synthetic skin substitutes have been evaluated over the last thirty years. These include polymer silicon membrane,[6] Hydron,[7] and Op-Site.[8]

The temporary composite biosynthetic substitutes that have been used over the last 20 years include Biobrane[9] and aldehyde-treated porcine skin (E.Z. Derm).[10] Biobrane consists of a custom-knit nylon fabric; bonded to an ultrathin silicon rubber membrane to which collagenous peptides are bonded, Biobrane has pores to provide better exudate drainage.

E.Z. Derm perforated porcine biosynthetic wound dressing (manufactured by Brennen Medical, Inc. 1290 Hammond Road, St Paul, MN 55110) is a porcine-derived xenograft in which the collagen has been cross-linked with an aldehyde. It is well established that human cadaver skin (allograft) is superior to any temporary biological dressing. Since human cadaver skin is expensive, is not always available, or cannot be used owing to religious reasons, both Biobrane and aldehyde-treated porcine skin (E.Z. Derm) have enjoyed popularity as biosynthetic dressings.

The purpose of this retrospective study was to evalu-

ate the therapeutic effect of both aldehyde-treated porcine skin and Biobrane in the treatment of excised full-thickness burns as temporary biosynthetic wound coverings. The study is unique - there is little to be found in the literature on the subject.

## Patients and methods

Data collection methods: 52 patients (42 males and 10 females) with deep dermal and full-thickness burns were selected for this retrospective study. Half of these patients were treated with Biobrane, in the period January 1995-December 1999, and the other half were treated with E.Z. Derm (January 2000-December 2005). The mean age was 35 years and the mean total body surface area (TBSA) burned was 30%. All the patients underwent either tangential excision or excision down to the muscle fascia.

Data collection included:

1. Initial observation: patient age, sex, extent of burns, depth of burns, distribution of burns, patient consent, photograph
2. Skin substitute observation: adherence, presence of fluid collection under the substitute, area of rejection, evidence of infection based upon clinical and laboratory observations, antigenicity, systemic toxicity
3. Follow-up wound evaluation: percentage autograft take, cosmetic appearance of the wound, photograph
4. The initial evaluation form was completed prior to the operative procedure. Skin substitutes were evaluated at the time of the initial post-operative dressing removal (3-5 days post-operatively). Additional observations and documentation were performed every other day until the area was ready for autografting (or healed by primary re-epithelialization). The autograft was evaluated and observations documented at the time of dressing removal and at day 10 post-operatively.

*Inclusion/exclusion criteria*

1. Patients admitted with full-thickness and deep dermal burns
2. Patients with 25% or greater TBSA burn
3. Patients aged 18 years or over
4. Both Biobrane and E-Z Derm were applied on similar burn wounds but not on the same patient

*Methods of application*

Both the deep dermal and the full-thickness burns were excised either tangentially or down to the muscle fascia. The excisional therapy was carried out in stages, and each excisional procedure was limited to 7 to 15% TBSA. The wound was washed with sterile saline, and good haemostasis was achieved using topical epinephrine solution. The substitute was placed and held in place with surgical staples. Biobrane was applied fabric-side down and wrapped.

*Case reports* (see *Tables I* and *II*)

**Table I** - Case reports: patients treated with Biobrane

| Patient No. | Age (yr) | Sex | TBSA | TBSA treated with Biobrane | Surgical procedure | Bacteriological study | Adherence | Replacement (post-application) | Autograft take |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 30 | M | 30% | 10% | Tangential excision of burn wounds on day 4 post-burn. Biobrane applied on anterior and lateral chest wall | No growth | Adherent | Biobrane removed on day 10 and replaced with autograft | 100% |
| 3 | 29 | F | 45% | 5% | Biobrane applied on right abdomen | *Acinetobacter* | Partially adherent. Collection of exudates | Non-adherent part replaced with silver sulphadiazine on day 11 | 100% |
| 7 | 20 | F | 23% | 3% | Biobrane applied on left forearm | No growth | Adherent | No | 100% |
| 12 | 41 | M | 27% | 4% | Biobrane applied on back on day 4 post-burn | No growth | Adherent | Biobrane removed on day 8 and replaced with autograft | 100% |
| 17 | 19 | M | 70% | 10% | Abdominal wall | Gram negative rods, *Strept.* and *Staph.* | Partially adherent. Collection of exudates | Non-adherent part replaced with Sofratull on day 5 post-application | 90% |
| 26 | 58 | M | 50% | 8% | Both forearms | No growth | Adherent | Removed on day 15 and replaced with autograft | 100% |

**Table II** - Case reports: patients treated with E.Z. Derm

| Patient No. | Age (yr) | Sex | TBSA | TBSA treated with E.Z Derm | Surgical procedure | Bacteriological study | Adherence | Replacement (post-application) | Autograft take |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 25 | M | 40% | 15% | E.Z. Derm applied on right leg and thigh | Scanty gram-positive bacilli | Partial adherent | On day 3, replaced with another E.Z Derm | 100% |
| 3 | 42 | M | 57% | 10% | Applied on right abdominal wall | No growth | No adherence | On day 3, replaced with skin graft | 100% |
| 6 | 36 | M | 34% | 20% | Applied on both lower limbs | Scanty gram-positive bacilli | Adherent | On day 5, replaced with skin graft | 100% |
| 10 | 25 | M | 80% | 20% | Abdominal wall and lower limbs | Gram-positive bacilli | Partially adherent | Replaced every 3 days | Partial graft take 80% |
| 16 | 15 | M | 43% | 10% | Both lower limbs | No growth | Adherent | On day 5, replaced with skin graft | 100% |
| 20 | 30 | M | 30% | 12% | Both upper limbs | No growth | Partially adherent | Replaced with another E.Z. Derm | 100% take |
| 26 | 31 | F | 40% | 15% | Both thighs and buttocks | No growth | No adherence | Replaced with skin graft on day 4 | 100% graft take |

## Results

The mean age of the patients was 35 years and the mean TBSA burned was 30%. The study showed no adverse reaction or systemic complications in either Biobrane or E.Z. Derm. The excised full-thickness burn wounds treated with Biobrane had the same mean percentage autograft take as E.Z. Derm-covered burn wounds. Upon removal of both skin substitutes, the granulating wound bed was appropriate for skin autografting. Haematoma formation was observed in four cases undergoing Biobrane treatment. Infected fluid underneath Biobrane was reported in three cases. Both conditions interfered with the adherence of Biobrane and necessitated removal and replacement with another dressing. The change of Biobrane dressing was done at 7-10 days. Patients treated with E.Z. Derm showed no collection underneath the dressing because of the presence of perforations. All patients underwent a dressing change at 3-4 days because of limited adherence, and bacteriological studies revealed growth of bacteria in three patients. The E.Z. Derm dressing was more flexible and more elastic on application, especially when applied on joints and extremities. E.Z. Derm is more haemostatic than Biobrane and both dressings showed ease of application and removal (*Table III*).

## Discussion and conclusions

Tissue-engineered skin is a significant advance in the field of wound healing and was developed owing to limitations associated with the use of autografts. These limitations include the creation of a donor site, which is at risk of developing pain, scarring, infection, and/or slow healing. A number of products are commercially available and many others are in development. Cultured epidermal autografts[11] can provide permanent coverage of a large area from a skin biopsy. However, three weeks are needed for graft cultivation. Cultured epidermal allografts[12] are available immediately and no biopsy is necessary. Grafts can be cryopreserved and banked, but are not currently commercially available. A non-living allogenic acellular dermal matrix with intact basement membrane complex (AlloDerm) is immunologically inert.[13] It prepares the wound bed for grafting, allowing improved cultured allograft take and provides an intact basement membrane. A non-living extracellular matrix of collagen and chondroitin-6-sulphate with silicone backing (Integra) serves to generate neodermis.[14] A collagen and glycosaminoglycan dermal matrix inoculated with autologous fibroblasts and keratinocytes has been investigated.[15] It requires 3 to 4 weeks for cultivation. Dermagraft[16] consists of living allogenic dermal fi-

**Table III** - Properties of Biobrane vs E.Z. Derm

| Properties | Antigenicity | Systemic toxicity | Elasticity | Durability | Adherence | Antiseptic effect | Haemostatic | Ease of application and removal | Shelf storage |
|---|---|---|---|---|---|---|---|---|---|
| Biobrane | +/- | 0 | + | + | + | +/- | +/- | + | + |
| E.Z. Derm | 0 | 0 | + | + | +/- | +/- | + | + | + |

\+ = Excellent
+/- = Variable
0 = None

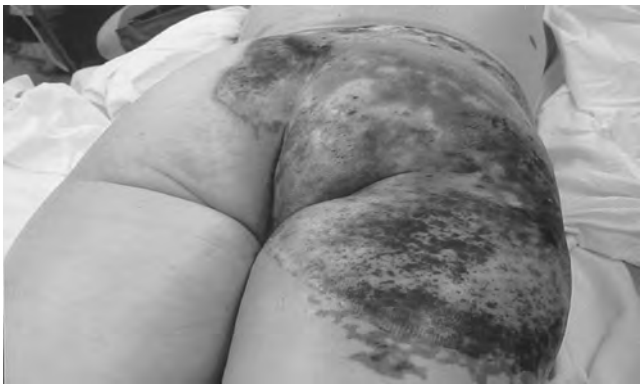

**Fig. 1** - 31-yr-old female with flame full-thickness burns in the buttocks and both thighs.

**Fig. 2** - Burn wound in the buttocks tangentially excised on day 5 post-burn, covered immediately with E.Z. Derm.

**Fig. 3** - Applied E.Z. Derm prior to removal.

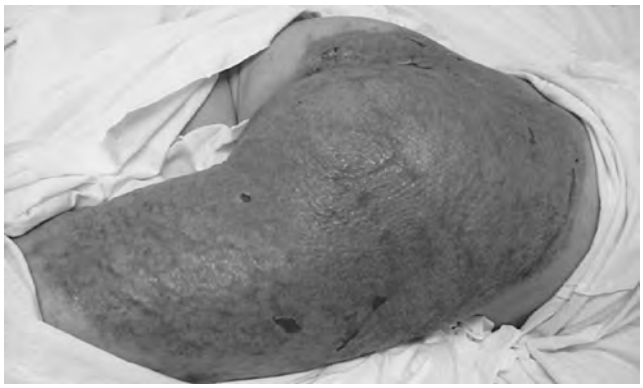

**Fig. 4** - One month post-operative. Stable wound healing achieved.

broblasts grown on a degradable scaffold. It has good resistance to tearing. An extracellular matrix generated by allogenic human dermal fibroblasts serves as a matrix for neodermis generation. Limited data are available for porcine small intestinal submucosa acellular collagen matrix (Oasis),[17] a product with a long shelf life.

The potential risks and benefits of using tissue-engineered skin need to be further evaluated in clinical trials but it is obvious that they offer a new option for wound treatment. The constant progress in technology has now made it possible to produce numerous synthetic and biosynthetic biological substitutes capable of replacing skin.

The skin substitutes now available can be divided into three categories, depending on their origin and physicochemical composition:

A. biological skin substitutes
B. synthetic skin substitutes
C. biosynthetic skin substitutes

Among the biological covering materials the following are of particular importance:

- homologous skin
- pigskin
- human amniotic membrane
- collagen derivatives
- cultured allografts

The most widely used substitute of this kind was pigskin, because of its greater affinity to human skin. Pigskin was used first fresh and then lyophilized[3] because it was easily preserved and immediately made available for use after immersion in physiological solution.

In recent years other preparations have been employed, among which we can mention glutaraldehyde pigskin impregnated with silver ions[18] and glycerinized pigskin conjugated with aldehydes (E.Z. Derm).[19,20] Conjugation with aldehydes, in particular, makes the skin antigenically inert without any negative effect on the structural integrity of the biological material, demonstrating overall retention ten times as great as an untreated xenograft.

Biobrane consists of a double synthetic sheet covered on both sides by peptides obtained from porcine collagen. Biobrane constitutes an outstandingly effective barrier for water vapour losses and it also has considerable capacity for adherence to lesions, provided that haemostasis is carefully performed. We have used Biobrane, which has shown

itself to be a valid substitute in the treatment of intermediate bums and escharectomized areas.

Biobrane has numerous perforations for the draining of fluids and the passage of disinfectants. We have observed that Biobrane adheres for long periods, protecting the lesions from pollution and desiccation and at the same time preparing the wound for autografting.

To obviate the above problems, for a number of years we have used pigskin conjugated with aldehydes and impregnated with silver ions (E-Z Derm).

This preparation combines an antibacterial effect with a lower antigenic power and can remain longer on excised wounds. The preparation's network technique prevents accumulations of blood and pus, which makes it possible to carry out observations every three or four days.

**RÉSUMÉ**. *Eléments de base*. L'emploi de substituts de peau comme couverture temporaire ou permanente est le sujet de recherche et d'étude depuis l'an 1500 av. J.-C. La couverture temporaire des brûlures peut réduire le taux métabolique, la perte des liquides et la colonisation. Dans cette étude les Auteurs se proposent d'examiner les expériences cliniques avec Biobrane et avec la peau porcine traitée avec aldéhyde (E.Z. Derm) comme substitut biosynthétique dans le traitement des brûlures excisées. *Méthodes*. Pour cette étude rétrospective 52 patients (42 mâles et 10 femelles) atteints de brûlures dermiques profondes et de toute épaisseur ont été sélectionnés. La moitié de ces patients ont été traités avec Biobrane (pendant la période janvier 1995/décembre 1999) et l'autre moitié avec E.Z. Derm (janvier 2000/décembre 2005). La surface corporelle totale (SCT) moyenne brûlée était de 30%. La thérapie excisionnelle a été effectuée en phases où chaque procédure était limitée à 7-15% de la SCT. Tous les patients ont subi ou l'excision tangentielle ou l'excision jusqu'au fascia musculaire. Le rapport mâle/femelle était de 3:1 et l'âge variait entre 5 et 67 ans (moyen, 35 ans). La collection des données incluait: l'observation initiale (âge, sexe, extension et profondeur de la brûlure, photographie), observation du substitut de la peau (adhérence, présence of liquides, rejet, infection, photographie) et suivi de l'évaluation de la lésion. *Résultats*. Soit le Biobrane soit l'E.Z. Derm réduisaient la douleur, diminuaient les pertes hydriques et thermiques et limitaient la croissance bactérienne. Tous les deux diminuaient les pertes exudatives protéiques, protégeaient les vaisseaux et les nerfs et amélioraient la guérison des lésions d'épaisseur variable. Tous les deux favorisaient le développement des tissus de granulation pour la préparation des autogreffes, et ni l'un ni l'autre ne présentait aucune antigénicité ni maladies transmises. La peau porcine présentait une adhésion limitée à la lésion et un contrôle limité de l'infection par rapport au Biobrane. *Conclusion*. Le Biobrane et le E.Z. Derm protégeaient les lésions par brûlure excisées de la contamination bactérienne et de la déshydratation. On peut conclure que le Biobrane a la capacité potentielle de l'adhérence sur le long terme (10 jours). La peau porcine traitée avec l'aldéhyde (E.Z. Derm) est un instrument utile pour l'emploi à bref terme et ne doit pas rester en contact avec la lésion plus de 3-4 jours.

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