

Skin Substitutes in Burn Management: A Practical Review

**Santiago González Gómez¹, Emmanuel Alejandro Saucedo Resendiz², Rafael Chávez Contreras³,
María Fernanda Páez Arteaga⁴**

^{1,2}Centro Médico Nacional del Noreste, IMSS, Monterrey, Nuevo León.

¹<https://orcid.org/0009-0002-1580-5576>

²<https://orcid.org/0009-0007-9453-823X>

³Hospital Civil de Guadalajara Fray Antonio Alcalde, Guadalajara, Jalisco. <https://orcid.org/0009-0002-2298-527X>

⁴Centro Médico Nacional del Noreste, IMSS, Monterrey, Nuevo León. <https://orcid.org/0009-0005-7483-1979>

ABSTRACT

This review examines the diverse landscape of skin substitutes used in burn management, highlighting their classification based on composition—biological, synthetic, and bioengineered—and structural function—epidermal, dermal, and composite. Skin substitutes serve critical roles in restoring skin integrity, preventing infection, and promoting healing, especially when autologous grafts are limited. Recent advances, such as off-the-shelf decellularized matrices and 3D bioprinting, show promise for personalized and efficient skin regeneration. The review emphasizes that successful wound healing depends not only on the choice of skin substitute but also on complementary dressing strategies that maintain optimal moisture, prevent infection, and support graft integration. A tailored combination of suitable dressings (e.g., hydrocolloids, alginates, foams, hydrogels) enhances healing outcomes. Overall, an integrated approach leveraging advanced materials and dressing techniques is vital for optimal burn wound management and patient recovery.

KEYWORDS: Skin substitutes, burn management, biological and synthetic skin grafts, tissue engineering, wound healing

ARTICLE DETAILS

Published On:
18 June 2025

Available on:
<https://ijmscrs.com/>

INTRODUCTION

Skin substitutes are a heterogeneous group of biological, synthetic, or bioengineered materials designed to temporarily or permanently replace the structure and function of the skin, particularly in the management of acute and chronic wounds such as burns. Their primary roles in burn management are to restore the cutaneous barrier, reduce fluid loss, prevent infection, and promote wound healing when autologous skin grafts are unavailable or insufficient due to extensive injury.[1-7]

Skin substitutes can be classified by composition and function:

1. By composition:

- Biological substitutes: Derived from human (allogeneic) or animal (xenogeneic) tissues, including cadaveric skin (allograft), porcine skin (xenograft), and acellular dermal matrices. These may be cellular (containing living cells) or acellular.[1][3][5-7]

- Synthetic substitutes: Composed of synthetic polymers or semisynthetic materials, often designed to mimic the extracellular matrix and support cellular infiltration and neovascularization.[1][3][6]

- Bioengineered/tissue-engineered substitutes: Combine scaffolds (biological or synthetic) with cultured cells (keratinocytes, fibroblasts) to create constructs that more closely resemble native skin.[1][8][5-6]

2. By function and structure:

- Epidermal substitutes: Provide a temporary or permanent epidermal layer, e.g., cultured epithelial autografts (CEA).[3][5]

- Dermal substitutes: Replace or regenerate the dermal layer, often used as a scaffold for subsequent epidermal coverage, e.g., collagen-glycosaminoglycan matrices.[3][5-6]

- Composite (dermoepidermal) substitutes: Aim to replicate both dermal and epidermal layers, sometimes using

Skin Substitutes in Burn Management: A Practical Review

autologous or allogeneic cells seeded onto a scaffold.[1][8][5-6]

Clinical application in burn management:

- For superficial partial-thickness burns, skin substitutes may be used to accelerate healing and reduce pain, with products such as Biobrane commonly employed.[9]
- In deep partial-thickness and full-thickness burns, especially when donor sites are limited, skin substitutes serve as temporary wound coverage (e.g., allografts, xenografts, synthetic dermal matrices) or as part of staged reconstruction, often in combination with autologous skin grafts.[2][9][7]
- Permanent skin substitutes (e.g., autologous engineered skin, bilayered constructs) are under active development and may be used for definitive wound closure, though none fully replicate the structure and function of uninjured skin.[8]

- The choice of substitute depends on burn depth, wound size, availability of donor skin, risk of infection, and institutional protocols. There is significant variability in product selection and use across burn centers, and high-quality comparative evidence is still lacking.[9]
- Recent advances include the development of off-the-shelf decellularized dermal matrices that can be recellularized with patient-derived cells, offering the potential for rapid, personalized skin substitute production with improved mechanical and histological properties.[1][8] However, autologous split-thickness skin grafting remains the gold standard for definitive closure of extensive burns, with skin substitutes primarily serving as adjuncts or temporizing measures.[2][4-5][7]

CATEGORY	TYPE/FEATURES	FUNCTION	APPLICATION
BIOLOGICAL SUBSTITUTES	Allografts (cadaveric skin)	Temporary/long-term skin replacement	Deep burns, temporary coverage
	Xenografts (porcine skin)	Temporary coverage	Acute burns, breach of infection barriers
SYNTHETIC SUBSTITUTES	Acellular matrices	Scaffold for cellular infiltration	Wound healing facilitation
	Polymer-based scaffolds	Mimic extracellular matrix, support tissue growth	Burn wound coverage, deep injuries
BIOENGINEERED/TISSUE-ENGINEERED	Cell-seeded constructs	Resemble native skin, potentially permanent solutions	Full-thickness burns, regenerative therapies
STRUCTURAL TYPES	Epidermal substitutes (e.g., CEA)	Cover epidermis, temporary or permanent	Superficial and partial-thickness burns
	Dermal substitutes (e.g., collagen matrices)	Rebuild dermis, support vascularization	Deep partial/full-thickness burns
	Composite (dermoepidermal) constructs	Replace both dermal and epidermal layers	Extensive burns requiring layered restoration
EMERGING TECHNOLOGIES	Decellularized dermal matrices	Off-the-shelf, customizable skin scaffolds	Rapid, personalized skin regeneration
	3D bioprinting	Precise, custom-designed skin tissues	Advanced regenerative therapy
GOALS OF SKIN SUBSTITUTES	Barrier restoration, infection prevention, healing promotion	Accelerate healing, reduce pain	Burn wounds, large or complex injuries

Optimizing Wound Healing: The Interplay Between Skin Grafts, Substitutes, and Dressings

While the application of grafts and skin substitutes plays a crucial role in restoring skin integrity, their success heavily depends on the wound environment, which is significantly influenced by the choice of wound dressings [10-13]. Appropriate dressings are essential not only for maintaining optimal moisture balance and preventing infection but also for supporting the integration, revascularization, and reepithelialization of grafts and substitutes. For instance, moisture-retentive dressings like hydrogels or hydrocolloids

can promote reepithelialization, while absorptive dressings such as alginates and foams are beneficial in exudative wounds, ensuring the wound environment remains conducive to healing. The selection of dressing type should be tailored to the specific stage of healing and the wound's characteristics, as an unsuitable dressing can compromise graft survival, impede revascularization, or cause trauma to delicate grafted tissue [10-13]. Thus, the synergy between an appropriate graft or substitute and the optimal dressing strategy is fundamental to achieving successful wound closure and functional recovery.

Skin Substitutes in Burn Management: A Practical Review

Consideration of dressing properties—moisture management, antimicrobial activity, and conformability—should be an integral part of the treatment plan to enhance graft integration and expedite healing [10-13].

Hydrocolloids are occlusive, moisture-retentive dressings that facilitate autolytic debridement and are impermeable to bacteria. They are contraindicated in infected wounds and should be used with caution on fragile skin, as removal may cause skin trauma. Hydrocolloids are preferred for low-to-moderate exudate wounds and superficial burns, but not for wounds with heavy exudate or clinical infection.[10-12]

Alginates are highly absorbent and conformable, making them suitable for wounds with moderate to heavy exudate, such as burns with abundant exudate. They require a secondary dressing and are not appropriate for dry wounds or wounds with minimal exudate, as they may desiccate the wound bed. Alginates can be combined with antimicrobials if infection is a concern.[11, 12]

Foam dressings are also absorptive and can be used under compression. They are indicated for wounds with moderate exudate and are commonly used in burns with significant drainage. They are not suitable for dry wounds or those with minimal exudate. There is no evidence that foam dressings are superior to other standard dressings in terms of healing outcomes.[10, 11, 13]

Hydrogels provide moisture and are indicated for dry or minimally exudative wounds, including some superficial burns. They are contraindicated in wounds with heavy exudate, as they may cause maceration. [10, 11, 13]

Gauze is highly permeable and is generally not recommended as a primary dressing for burns or chronic wounds due to its lack of moisture retention and potential for adherence to the wound bed, which can cause trauma on removal. Gauze is more appropriate for wound cleansing, as a cover dressing, or for packing deep wounds, but not as a primary dressing for optimal healing. [11, 12]

Collagen dressings are available in various forms and can stimulate wound healing. They are generally contraindicated in infected wounds and may require removal if not fully absorbed, depending on the product.[12]

Composite dressings combine multiple functions (e.g., absorption, adhesion, antimicrobial activity) and can be tailored to wound needs. Their contraindications depend on the components included.[12]

For wounds in high-tension or high-mobility areas (e.g., joints), dressings that are flexible, conformable, and have good adhesive properties (such as certain foams or composite dressings) are preferred to maintain coverage and minimize shear. [10-12]

Combination dressing strategies are sometimes recommended, particularly in complex wounds. For example, an absorptive primary dressing (e.g., alginate) may be covered with a secondary foam or film dressing to optimize moisture balance and protection. In wounds with both dry and exudative areas, different dressings may be used in different zones. The use of antimicrobial dressings (e.g., silver-impregnated) may be considered short-term in infected or high-risk wounds, but is not recommended for long-term use.[10, 11, 13]

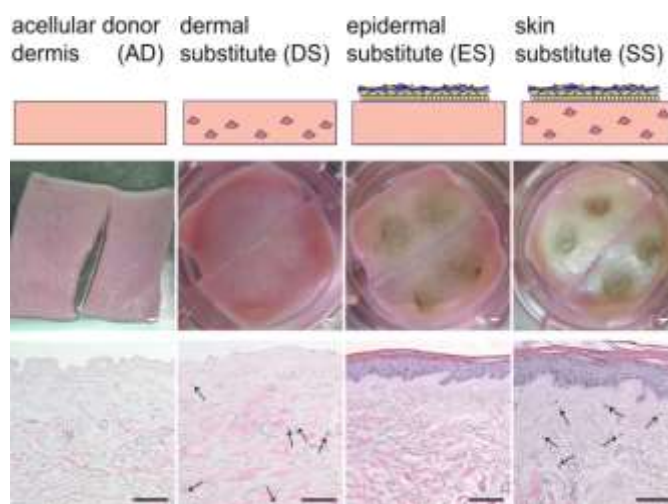


Figure 1. Overview of the skin substitutes. Upper panels show macroscopic view and lower panels show haematoxylin and eosin staining of tissue sections of AD, DS, ES and SS. Arrows indicate fibroblasts in the dermis. White bars represent 1000 µm and black bars 100 µm [14]

CONCLUSION

In summary, skin substitutes and grafts—whether biological, synthetic, or bioengineered—are central to burn management, providing essential functions such as barrier restoration, fluid regulation, and infection prevention. However, their success is intimately linked to the selection of appropriate dressings

that optimize the healing environment. Understanding how different dressing strategies support graft and substitute integration can significantly influence clinical outcomes, emphasizing the importance of a holistic approach to wound care. Ongoing innovations aim to develop integrated solutions that combine advanced graft materials with

dressings designed to maximize healing potential and improve patient recovery.

REFERENCES

- I. Kondej K, Zawrzykraj M, Czerwicz K, et al. Bioengineering Skin Substitutes for Wound Management-Perspectives and Challenges. *International Journal of Molecular Sciences*. 2024;25(7):3702. doi:10.3390/ijms25073702.
- II. Greenhalgh DG. Management of Burns. *The New England Journal of Medicine*. 2019;380(24):2349-2359. doi:10.1056/NEJMra1807442.
- III. Goodarzi P, Falahzadeh K, Nematizadeh M, et al. Tissue Engineered Skin Substitutes. *Advances in Experimental Medicine and Biology*. 2018;1107:143-188. doi:10.1007/5584_2018_226.
- IV. Chogan F, Chen Y, Wood F, Jeschke MG. Skin Tissue Engineering Advances in Burns: A Brief Introduction to the Past, the Present, and the Future Potential. *Journal of Burn Care & Research*. 2023;44(Suppl_1):S1-S4. doi:10.1093/jbcr/irac127.
- V. Boyce ST, Kagan RJ. Composition and Performance of Autologous Engineered Skin Substitutes for Repair or Regeneration of Excised, Full-Thickness Burns. *Journal of Burn Care & Research*. 2023;44(Suppl_1):S50-S56. doi:10.1093/jbcr/irac107.
- VI. Nyame TT, Chiang HA, Leavitt T, Ozambela M, Orgill DP. Tissue-Engineered Skin Substitutes. *Plastic and Reconstructive Surgery*. 2015;136(6):1379-1388. doi:10.1097/PRS.0000000000001748.
- VII. Łabuś W, Kitala D, Szapski M, et al. Tissue Engineering in Skin Substitute. *Advances in Experimental Medicine and Biology*. 2021;1345:193-208. doi:10.1007/978-3-030-82735-9_16.
- VIII. Magne B, Demers A, Savard É, et al. Speeding Up the Production of Clinical-Grade Skin Substitutes Using Off-the-Shelf Decellularized Self-Assembled Dermal Matrices. *Acta Biomaterialia*. 2023;167:249-259. doi:10.1016/j.actbio.2023.05.053.
- IX. Lee A, McKean AR, Wormald JCR, et al. A Clinician Survey of Skin Substitute Use in Burns Care in the UK and Ireland: The CASSIUS Study. *Journal of Plastic, Reconstructive & Aesthetic Surgery*. 2025;102:238-246. doi:10.1016/j.bjps.2025.01.064.
- X. Singer AJ, Tassiopoulos A, Kirsner RS. Evaluation and Management of Lower-Extremity Ulcers. *The New England Journal of Medicine*. 2017;377(16):1559-1567. doi:10.1056/NEJMra1615243.
- XI. Gallagher KA, Mills JL, Armstrong DG, et al. Current Status and Principles for the Treatment and Prevention of Diabetic Foot Ulcers in the Cardiovascular Patient Population: A Scientific Statement From the American Heart Association. *Circulation*. 2024;149(4):e232-e253. doi:10.1161/CIR.0000000000001192.
- XII. Skórkowska-Telichowska K, Czemplik M, Kulma A, Szopa J. The Local Treatment and Available Dressings Designed for Chronic Wounds. *Journal of the American Academy of Dermatology*. 2013;68(4):e117-e126. doi:10.1016/j.jaad.2011.06.028.
- XIII. Hingorani A, LaMuraglia GM, Henke P, et al. The Management of Diabetic Foot: A Clinical Practice Guideline by the Society for Vascular Surgery in Collaboration With the American Podiatric Medical Association and the Society for Vascular Medicine. *Journal of Vascular Surgery*. 2016;63(2 Suppl):3S-21S. doi:10.1016/j.jvs.2015.10.003.
- XIV. Monsuur, H. N., Weijers, E. M., Gibbs, S., & van den Broek, L. J. (2019). Skin substitutes are more potent than dermal or epidermal substitutes in stimulating endothelial cell sprouting. *BMC Biomedical Engineering*, 1, 1-7.