

Modern Approaches to Burn Management: The Role of Skin Substitutes

David Rodríguez Arevalo¹, Roberto Carlos Góngora Parga¹, Omar González Catañeda²

¹Hospital Regional Universitario, IMSS Bienestar

²Hospital Civil Fray Antonio Alcalde

ABSTRACT

Skin substitutes are a diverse group of biological, synthetic, and bioengineered materials designed to temporarily or permanently replace skin tissue in burn management. They serve critical functions such as restoring the skin barrier, promoting wound healing, reducing infection risk, and facilitating reconstruction when autologous grafts are limited. Classifications based on composition include biological (allografts, xenografts), synthetic, and tissue-engineered scaffolds, while functional classifications include epidermal, dermal, and composite substitutes. Clinical applications range from accelerating healing in superficial burns to staged reconstructions in full-thickness injuries. Recent advancements focus on personalized, off-the-shelf matrices and tissue-engineered constructs. Despite ongoing progress, autologous skin grafting remains the gold standard, highlighting the need for continued innovation to develop skin substitutes that closely emulate native skin's structure and functionality.

KEYWORDS: Skin substitutes, burn management, biological scaffolds, synthetic grafts, tissue engineering, wound healing, skin regeneration, autografts, allografts, bioengineered skin

ARTICLE DETAILS

Published On:
27 June 2025

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

INTRODUCTION

Skin substitutes constitute a diverse group of biological, synthetic, and bioengineered materials engineered to temporarily or permanently replace the skin's structure and function. They are primarily used in the management of acute and chronic wounds, such as burn injuries, to restore the skin barrier, minimize fluid loss, prevent infection, and promote healing, especially when autologous skin grafts are limited or insufficient.

These substitutes can be categorized based on their composition and functional characteristics.

Composition-Based Classification:

Biological substitutes are derived from human tissues (allografts) like cadaveric skin, or from animal tissues (xenografts) such as porcine skin. They may be cellular, containing living cells, or acellular, serving as scaffolds.

Synthetic substitutes consist of engineered polymers or semisynthetic materials designed to emulate the extracellular matrix, supporting cellular infiltration and blood vessel formation.

Bioengineered or tissue-engineered substitutes combine biological or synthetic scaffolds with cultured cells like keratinocytes and fibroblasts to produce constructs akin to natural skin.

Function and Structural Classification:

Epidermal substitutes provide an epidermal layer, either temporarily or permanently, exemplified by cultured epithelial autografts.

Dermal substitutes aim to regenerate or replace the dermal layer, often serving as a scaffold for subsequent epidermal coverage, such as collagen-based matrices.

Composite or dermoepidermal substitutes are designed to reconstruct both dermal and epidermal layers simultaneously, frequently utilizing cell-seeded scaffolds.

Acellular skin substitutes aim to provide biocompatible scaffolds for wound healing, with key examples like Alloderm® and Integra®. Alloderm®, developed in 1992, is processed from cadaveric dermis to remove cellular components, reducing immunogenicity and serving as an effective scaffold for burn treatment, though it is not suitable as a permanent replacement due to immune rejection. Integra® is a bi-layered synthetic dermal substitute combining bovine collagen with shark chondroitin sulfate, followed by a silicone epidermal layer; it promotes tissue regeneration and, after 2-4 weeks, can be overlaid with autologous skin grafts. While Integra® shows superior elasticity compared to traditional autografts, it involves multiple surgeries and potential infection risks.

Modern Approaches to Burn Management: The Role of Skin Substitutes

Other acellular substitutes include Biobrane®, a biosynthetic bilaminar membrane used temporarily to expedite healing, and Matriderm®, a bovine collagen-elastin matrix that supports immediate skin grafting with rapid matrix resorption and promising functional outcomes, particularly in hand burns.

Cellular allogeneic substitutes, such as Apligraf® and TransCyte®, incorporate living cells to promote healing. Apligraf® is a bilaminar construct containing neonatal fibroblasts and keratinocytes, stimulating cytokine release and vascularization, and improving graft integration and aesthetic outcomes. TransCyte®, composed of neonatal fibroblasts on a nylon mesh covered with silicone, accelerates re-epithelialization and is relatively easy to manage.

Cellular autologous skin replacements include cultured epidermal autografts (CEAs) and cultured skin substitutes (CSS). CEAs, developed since 1981, involve culturing keratinocytes from small biopsies to cover full-thickness wounds but are fragile and may cause scarring. CSS combines cultured keratinocytes and fibroblasts on a collagen scaffold to provide durable, permanent coverage, with advantages of minimal infection risk and improved integration, though they are costly and require lengthy preparation times.

Overall, these advanced biological and bioengineered skin substitutes expand the options for burn wound management, offering benefits such as improved healing, aesthetic outcomes, and functional restoration, with ongoing research focused on developing more durable and fully functional skin replacements.

Clinical Use in Burn Care:

For superficial partial-thickness burns, skin substitutes like Biobrane are used to expedite healing and reduce patient discomfort. In deeper partial-thickness and full-thickness burns, especially when donor skin is limited, these substitutes serve as temporary coverings or as part of staged reconstruction, often combined with autografts. Permanent skin substitutes, including tissue-engineered skin and bilayered constructs, are being developed for definitive wound closure, though none fully replicate natural skin's complexity.

The choice of skin substitute depends on factors such as burn depth, wound surface area, donor skin availability, infection risk, and institutional protocols. Variability exists across burn units, and there remains a lack of robust comparative studies. Recent innovations include decellularized dermal matrices that can be recellularized with patient-derived cells for personalized and rapid skin coverage solutions, with improved biomechanical and histological features. Nonetheless, autologous split-thickness skin grafting remains the gold standard for extensive burns, with skin substitutes mainly serving as adjuncts or temporary measures.

CONCLUSION

Skin substitutes represent a vital advancement in burn management, offering versatile options for wound coverage

when autologous skin is unavailable or insufficient. Their diverse types—ranging from biological and synthetic to bioengineered scaffolds—enable tailored approaches to facilitate wound healing, reduce complications, and improve functional and aesthetic outcomes. While recent innovations and ongoing research continue to enhance their efficacy and biological integration, autologous skin grafting remains the gold standard for definitive closure of extensive burns. Future developments in tissue engineering and regenerative medicine hold promise for creating more fully functional, durable, and skin-like substitutes, ultimately aiming to restore both the form and function of native skin more effectively.

REFERENCES

- I. Savoji H, Godau B, Hassani MS, Akbari M. Skin tissue substitutes and biomaterial risk assessment and testing. *Front Bioeng Biotechnol.* 2018 Jul 26;6:86. Also available: <http://dx.doi.org/10.3389/fbioe.2018.00086>. PMID: 30094235.
- II. Frykberg RG, Banks J. Challenges in the treatment of chronic wounds. *Adv Wound Care (New Rochelle).* 2015 Sep 1;4(9):560-82. Also available: <http://dx.doi.org/10.1089/wound.2015.0635>. PMID: 26339534.
- III. Snyder DL, Sullivan N, Schoelles KM. Skin substitutes for treating chronic wounds. Final report. Rockville (MD): Agency for Healthcare Research and Quality (AHRQ); 2012 Dec 18. 203 p. (Technology assessment report; Also available: http://www.ahrq.gov/research/findings/ta/skinsubs/HCPR0610_skinsubst-final.pdf).
- IV. Viswanathan M, Patnode CD, Berkman ND, Bass EB, Chang S, Hartling L, Murad MH, Treadwell JR, Kane RL. Recommendations for assessing the risk of bias in systematic reviews of health-care interventions. *J Clin Epidemiol.* 2018 May;97:26-34. Epub 2017 Dec 14. Also available: <http://dx.doi.org/10.1016/j.jclinepi.2017.12.004>. PMID: 29248724.
- V. Hingorani A, LaMuraglia GM, Henke P, Meissner MH, Loretz L, Zinszer KM, Driver VR, Frykberg R, Carman TL, Marston W, Mills JL Sr, Murad MH. 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. *J Vasc Surg.* 2016 Feb;63(2 Suppl):3S-21S. Also available: <http://dx.doi.org/10.1016/j.jvs.2015.10.003>. PMID: 26804367.