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(REVIEW ARTICLE)

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Graft harvesting and application: A comprehensive review

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Abstract

Background Skin grafting remains a cornerstone in reconstructive surgery. The procedure is essential in the management of burns, trauma, oncologic resections, and chronic wounds. Despite its historical relevance, new advances in surgical techniques and bioengineering have significantly expanded its applications.

Methods A systematic literature review was conducted in PubMed, Scopus, and Web of Science databases focusing on publications from 2000 to 2024. Keywords included *skin graft*, *harvesting techniques*, *integration physiology*, *bioengineered grafts*, and *complications*. Only studies related to surgery and bioengineering were included.

Results Autologous grafts remain the gold standard due to superior integration and reduced immunological rejection. However, acellular dermal matrices, stem cell–seeded scaffolds, and 3D-printed constructs represent promising alternatives. Integration physiology follows three phases: plasmatic imbibition, inosculation, and angiogenesis. Complication rates vary between 5–25%, with infection, necrosis, and graft failure as the most frequent.

Conclusion Traditional grafting techniques continue to demonstrate efficacy. Nonetheless, advances in regenerative medicine and bioengineering are paving the way for next-generation grafts that may offer enhanced survival, integration, and functional outcomes.

Keywords: Skin grafting; Harvesting techniques; Integration physiology; Bioengineered grafts; Complications

1. Introduction

Skin grafting is a cornerstone procedure in reconstructive surgery and has been employed for more than two millennia. Its principal aim is to provide definitive coverage of skin and soft tissue defects, restore barrier function, and improve both functional and aesthetic outcomes. The use of grafts remains indispensable in trauma surgery, burns, oncological resections, and chronic wounds where primary closure or local flap coverage is not feasible.

Despite its long history, the principles underlying graft survival continue to guide surgical practice. Adequate vascularization of the recipient bed, atraumatic handling of the graft, and careful postoperative care remain the key determinants of success. Recent advances in tissue engineering and biomaterials have broadened the reconstructive surgeon's armamentarium, offering promising alternatives to conventional grafting.

This review aims to provide a comprehensive overview of graft harvesting and application, focusing on surgical principles and recent advances in bioengineering. Emphasis is placed on the classification of grafts, their physiological integration, surgical techniques, clinical applications, complications, and future directions. 1,2,3

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2. Historical Background of Grafting

The concept of skin transplantation dates back to ancient India, where the *Sushruta Samhita* (circa 600 BCE) described nasal reconstruction using cheek flaps. Over the centuries, progressive refinements were made in Italy during the Renaissance and later in France and Germany during the 19th century. 3

The modern era of grafting began with the description of split-thickness and full-thickness skin grafts by Reverdin (1869), Ollier (1872), and Thiersch (1874). These pioneering techniques established the principles still in use today: the importance of graft thickness, donor site selection, and meticulous surgical handling. 3

By the 20th century, skin grafting became a standardized reconstructive method, particularly during the World Wars, when massive numbers of burn and trauma victims required coverage. The development of dermatomes further improved precision in harvesting split-thickness grafts. 4

Currently, skin grafting is one of the most frequently performed reconstructive procedures worldwide. Advances in microsurgery, wound bed preparation, and bioengineered substitutes have greatly expanded its utility, making it an essential tool in modern reconstructive and regenerative surgery. 5,6

2.1. Types of Grafts

Skin grafts can be classified according to their thickness, origin, and composition. Each category has specific clinical indications, advantages, and limitations. 6,7

2.1.1. According to Thickness

- **Split-thickness skin grafts (STSG):** Include epidermis and part of the dermis. They are the most commonly used type, harvested with dermatomes. STSGs demonstrate rapid revascularization but are prone to secondary contraction and less optimal cosmetic outcomes. 7
- **Full-thickness skin grafts (FTSG):** Contain the entire dermis and epidermis. They provide superior cosmetic and functional results, with reduced contraction, but require a well-vascularized recipient bed and present limited donor site availability. 7

2.1.2. According to Origin

- **Autografts:** Harvested from the patient's own skin. They remain the gold standard due to complete histocompatibility and lower risk of rejection. 7
- **Allografts:** Obtained from cadaveric or living donors. Frequently used as temporary biological dressings, particularly in burn patients, until autografting is feasible. 8
- **Xenografts:** Derived from another species (commonly porcine). Their use is mainly temporary and as biological coverage. 7,8

2.1.3. According to Composition

- **Composite grafts:** Contain multiple tissue layers such as skin, cartilage, or fat, used in nasal and auricular reconstructions. 8,9
- **Bioengineered grafts:** Artificially developed grafts using acellular dermal matrices, stem cells, or 3D bioprinting. They represent the frontier of regenerative medicine. 8.9

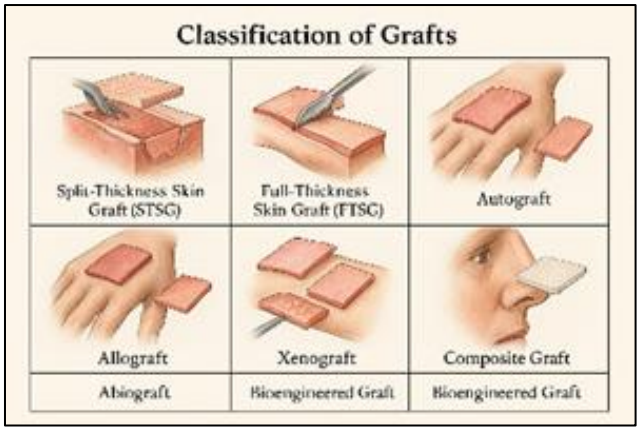

Figure 1 Classification of grafts according to thickness, origin, and composition

3. Physiology of Graft Integration

The survival of a skin graft is a dynamic process that depends on the interaction between the donor tissue and the recipient bed. Successful grafting requires three sequential physiological phases. 10

3.1. Plasmatic Imbibition (first 24–48 hours)

During the initial phase, the graft survives by absorbing plasma and nutrients through diffusion from the recipient bed. This provides temporary metabolic support until vascular connections are established. 10, 11

3.2. Inosculation (48–96 hours)

Capillary buds from the recipient bed begin to anastomose with vessels in the graft. This early vascular connection marks the transition from passive survival to active perfusion. 10, 11, 12

3.3. Revascularization (after day 4)

New capillaries grow into the graft through angiogenesis. This phase secures long-term survival and integration, allowing restoration of normal skin function.10, 11

Additional factors influencing integration include recipient site vascularity, absence of infection, atraumatic surgical handling, and immobilization of the graft during the first postoperative days. 12

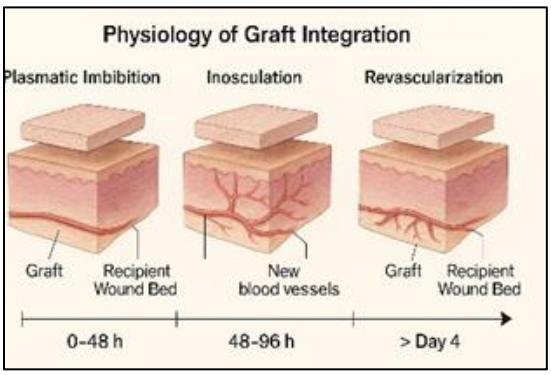

Figure 2 Physiological phases of graft integration: plasmatic imbibition, inosculation, and revascularization

4. Surgical Techniques and Harvesting Protocols

The success of grafting depends largely on meticulous surgical technique during harvesting, preparation, and application. 12

4.1. Donor Site Selection

Donor sites are usually chosen for their accessibility, ease of concealment, and similarity in skin characteristics to the recipient site. Common donor sites include the thigh, buttocks, and upper arm. 12

4.2. Harvesting of Split-Thickness Skin Grafts (STSG)

STSGs are harvested using an electric or manual dermatome, adjusting thickness according to the clinical need. A thinner graft favors rapid revascularization, while a thicker graft provides greater durability and cosmetic quality. 12

4.3. Harvesting of Full-Thickness Skin Grafts (FTSG)

These grafts are excised with a scalpel, including the entire dermis. Donor sites typically require primary closure due to the depth of harvest. FTSGs are indicated for areas requiring superior elasticity and color match, such as the face and hands. 12

4.4. Preparation of the Recipient Bed

The bed must be well vascularized, free from infection, necrosis, or exposed bone/tendon without periosteum or peritenon. Meticulous debridement is essential for successful integration. 12

4.5. Fixation of the Graft

Techniques include sutures, staples, or fibrin glue. Bolster dressings or negative pressure wound therapy (NPWT) may be applied to maintain immobilization and improve contact between graft and bed. 12

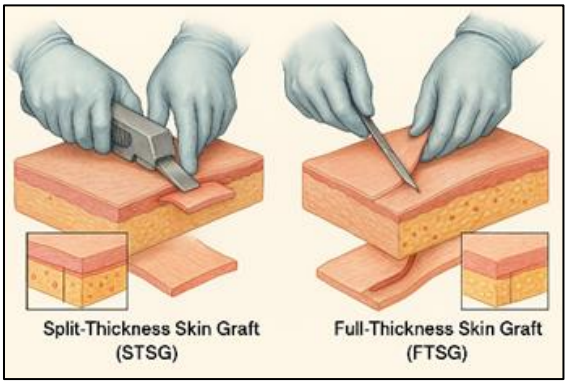

Figure 3 Harvesting of split-thickness and full-thickness skin grafts using dermatome and scalpel

5. Applications in Clinical Practice

Skin grafting is indicated when primary closure or local flap reconstruction is not feasible. Its versatility makes it a standard technique across multiple surgical specialties. 13, 14

5.1. Burn Surgery

In deep second- and third-degree burns, early excision and STSG application reduce mortality and infection risk. Sheet grafts are used for cosmetically sensitive areas, while meshed grafts allow coverage of extensive wounds. 13,14

5.2. Trauma and Soft Tissue Defects

Following trauma or tumor resection, grafts provide durable coverage, protect underlying structures, and accelerate wound healing. 13,14

5.3. Chronic Wounds

In venous ulcers, pressure sores, and diabetic foot lesions, grafts can provide coverage after optimizing vascularization and controlling infection. 13,14

5.4. Aesthetic and Functional Reconstruction

FTSGs are used in areas requiring superior cosmetic and functional outcomes, such as the eyelids, lips, and hands, where elasticity and color match are critical., 13,14

6. Oncologic Surgery

After wide local excision of skin cancers, grafts restore continuity and allow oncological surveillance of the surgical bed. 15

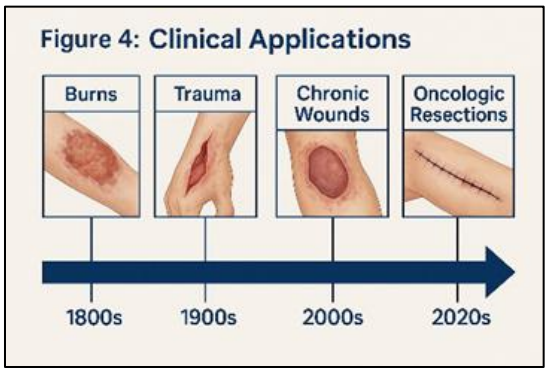

Figure 4 Clinical applications of grafts in burns, trauma, chronic wounds, and oncologic reconstruction

7. Complications and Risk Management

Although skin grafting is generally safe and effective, complications may occur and compromise graft survival or functional outcomes. Understanding these risks is essential for prevention and management. 15

7.1. Graft Failure

The most severe complication, often due to poor recipient bed vascularity, hematoma, infection, or excessive motion. Partial failure may be managed conservatively, while complete loss requires re-grafting. 15

7.2. Infection

Bacterial contamination delays revascularization and may lead to graft necrosis. Broad-spectrum antibiotics and strict aseptic technique are mandatory. 15

7.3. Hematoma and Seroma Formation

Collections of blood or fluid beneath the graft create a barrier to vascular ingrowth. Prevention includes meticulous hemostasis and the use of tie-over dressings or NPWT. 16

7.4. Contracture

Particularly associated with STSGs, contracture can limit mobility and cause aesthetic deformity. Physical therapy and, in some cases, surgical release are necessary. 16

7.5. Pigmentary Changes and Hypertrophic Scars

Alterations in color and texture may compromise cosmetic outcomes, especially in exposed areas. 15

7.5.1. Risk Mitigation Strategies

- Careful patient selection and optimization of comorbidities.

- Adequate debridement and bed preparation.
- Secure immobilization of the graft during early healing. 16

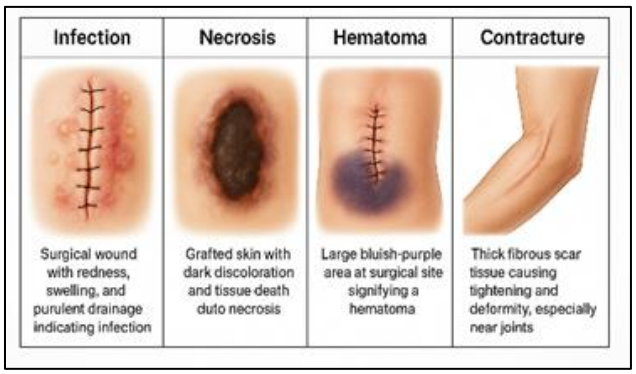

Figure 5 Common complications of grafting: infection, necrosis, hematoma, and contracture

8. Recent Advances in Bioengineering

In recent years, bioengineering has revolutionized the field of reconstructive surgery, offering innovative alternatives to traditional grafting. These technologies aim to improve graft survival, reduce donor site morbidity, and accelerate functional recovery. 17

8.1. Acellular Dermal Matrices (ADM)

ADM are scaffolds processed to remove cellular components while preserving the extracellular matrix. They serve as biological frameworks that promote vascular and cellular ingrowth, widely applied in burns and reconstructive procedures. 17

8.2. Stem Cell–Seeded Scaffolds

Mesenchymal stem cells (MSCs) can be seeded onto biocompatible scaffolds, enhancing angiogenesis and accelerating integration. Preclinical studies demonstrate improved survival and reduced rejection rates compared to conventional grafts. 17

8.3. 3D Bioprinting

This cutting-edge technology allows the layer-by-layer construction of patient-specific grafts using bio-inks composed of cells, growth factors, and biomaterials. Although still experimental, early clinical applications in skin substitutes are promising. 17

8.4. Growth Factors and Gene Therapy

Adjunctive therapies, such as vascular endothelial growth factor (VEGF) and platelet-derived growth factor (PDGF), have been studied to enhance angiogenesis and integration. Gene-modified grafts are being explored for long-term survival. 17,18

8.5. Smart Biomaterials

Novel materials capable of controlled drug release, antibacterial activity, and improved elasticity are under development, offering multifunctional grafts beyond simple coverage. 17,18

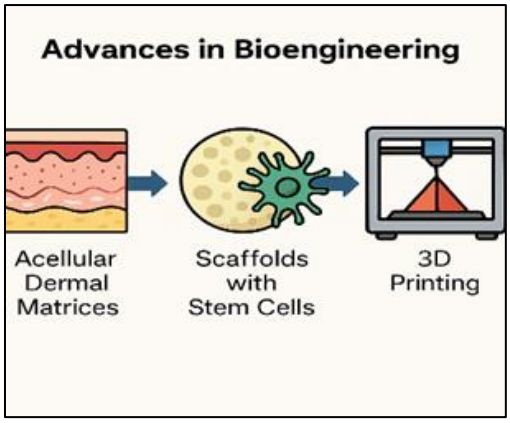

Figure 6 Advances in graft bioengineering: acellular dermal matrices, stem cell–seeded scaffolds, and 3D bioprinting

9. Discussion

Skin grafting remains a cornerstone in reconstructive surgery, with autografts continuing to serve as the gold standard due to their superior integration and histocompatibility. However, limitations such as donor site morbidity, limited availability, and variable cosmetic outcomes have spurred the search for alternatives.

The physiology of graft integration—through plasmatic imbibition, inosculation, and revascularization—remains a critical determinant of success. Any disruption of these processes, such as infection, hematoma, or shear forces, significantly increases the risk of failure. Thus, meticulous surgical technique, careful bed preparation, and optimal postoperative care are fundamental.

In clinical practice, grafting provides versatile solutions for burns, trauma, oncologic resections, and chronic wounds. Each clinical indication requires tailoring of graft type and harvesting technique to maximize outcomes. Full-thickness grafts provide superior aesthetic and functional results but are limited by donor site constraints, while split-thickness grafts allow for extensive coverage at the cost of increased contraction.

Recent advances in bioengineering have opened new horizons. Acellular dermal matrices, stem cell–based scaffolds, and 3D bioprinting represent promising innovations that may eventually replace or complement traditional grafts. Early clinical trials demonstrate encouraging results, though cost, accessibility, and regulatory approval remain challenges.

Ultimately, the future of grafting lies in the integration of regenerative medicine with classical surgical principles, providing patients with safer, more effective, and personalized solutions. 19,20

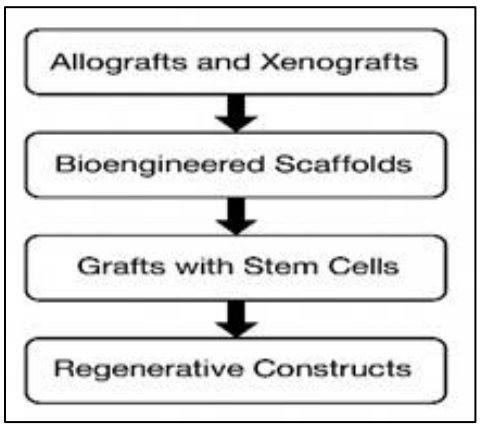

Figure 7 Integration of surgical and bioengineering approaches: from traditional autografts to advanced bioengineered constructs

10. Conclusion

Skin grafting continues to be a fundamental reconstructive surgical procedure, essential in the management of burns, trauma, oncologic resections, and chronic wounds. While autologous grafts remain the gold standard, their limitations have driven innovation in tissue engineering and regenerative medicine.

Understanding the physiology of graft integration and applying meticulous surgical technique remain the basis for successful outcomes. Complications such as infection, hematoma, and necrosis can be minimized by proper bed preparation, graft immobilization, and careful postoperative care.

Emerging bioengineered solutions—including acellular dermal matrices, stem cell–seeded scaffolds, and 3D bioprinting—represent the next frontier, offering the potential for personalized and regenerative approaches that may redefine the future of grafting.

In conclusion, the integration of surgical precision with bioengineering innovation offers the greatest promise for advancing reconstructive surgery and improving patient outcomes.

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References

[1] Atiyeh BS, Costagliola M, Hayek SN. Skin grafts and skin substitutes in burn management. Ann Burns Fire Disasters. 2005;18(1):19-25.

[2] Branski LK, Herndon DN, Celis MM, et al. Amnion-derived cellular cytokine solution modulates inflammation in vitro and in vivo. J Burn Care Res. 2009;30(2):248-57.

[3] Sheridan RL, Tompkins RG. Skin substitutes in burns. Burns. 1999;25(2):97-103.

[4] Jeschke MG, Van Baar ME, Choudhry MA, Chung KK, Gibran NS, Logsetty S. Burn injury. Nat Rev Dis Primers. 2020;6(1):11.

[5] Chester DL, Balderson DS, Papini RP. Skin substitutes and burns. Burns. 2004;30(6):S37-43.

[6] MacNeil S. Progress and opportunities for tissue-engineered skin. Nature. 2007;445(7130):874-80.

[7] Horch RE, Kopp J, Kneser U, Beier J, Bach AD. Tissue engineering of cultured skin substitutes. J Cell Mol Med. 2005;9(3):592-608.

[8] Griffiths M, Ojeh N, Livingstone R, Price R, Navsaria H. Survival of Apligraf in acute human wounds. Tissue Eng. 2004;10(7-8):1180-95.

[9] Boyce ST, Warden GD. Principles and practices for treatment of cutaneous wounds with cultured skin substitutes. Am J Surg. 2002;183(4):445-56.

[10] Auger FA, Berthod F, Moulin V, Pouliot R, Germain L. Tissue-engineered skin substitutes: from in vitro constructs to in vivo applications. Biotechnol Appl Biochem. 2004;39(Pt 3):263-75.

[11] Yannas IV. Emerging rules for inducing organ regeneration. Biomaterials. 2013;34(2):321-30.

[12] Supp DM, Boyce ST. Engineered skin substitutes: practices and potentials. Clin Dermatol. 2005;23(4):403-12.

[13] Shevchenko RV, James SL, James SE. A review of tissue-engineered skin bioconstructs available for clinical use. Burns. 2010;36(4):449-61.

[14] Halim AS, Khoo TL, Mohd Yussof SJ. Biologic and synthetic skin substitutes: An overview. Indian J Plast Surg. 2010;43(Suppl):S23-8.

[15] Metcalfe AD, Ferguson MW. Tissue engineering of replacement skin: the crossroads of biomaterials, wound healing, embryonic development, stem cells and regeneration. J R Soc Interface. 2007;4(14):413-37.

[16] Ng KW, Hutmacher DW. Reduced contraction of skin equivalent engineered using cell-immobilized biodegradable scaffold. Biomaterials. 2006;27(27):4591-8.

[17] Rheinwald JG, Green H. Serial cultivation of strains of human epidermal keratinocytes: the formation of keratinizing colonies. Cell. 1975;6(3):331-43.

[18] Lee SH, Jin SY, Song JS, Seo KK, Cho KH. Construction of tissue-engineered skin substitute using keratinocytes and fibroblasts from periorbital tissue. Tissue Eng Part A. 2009;15(7):1669-75.

[19] Burke JF, Yannas IV, Quinby WC Jr, Bondoc CC, Jung WK. Successful use of a physiologically acceptable artificial skin in the treatment of extensive burn injury. Ann Surg. 1981;194(4):413-28.

[20] Orgill DP, Yeh JT. Skin substitutes. Surg Clin North Am. 2007;87(1):189-207.

[21] Boyce ST. Cultured skin substitutes: a clinical review. Wound Repair Regen. 1996;4(2):166-76.

[22] Raghunath M, Bruckner P, Steinmann B. Delayed wound repair and dermal scarring in mice lacking collagen fibril-associated decorin. J Cell Biol. 1993;120(4):1031-40.

[23] Tocco I, Zavan B, Bassetto F, Vindigni V. Skin substitutes: an update. J Tissue Eng Regen Med. 2012;6(6):464-72.

[24] Debels H, Hamdi M, Abberton K, Morrison W. Dermal matrices and bioengineered skin substitutes: a critical review of current options. Plast Reconstr Surg Glob Open. 2015;3(1):e284.

[25] Veves A, Falanga V, Armstrong DG, Sabolinski ML. Graftskin, a human skin equivalent, is effective in the management of nonhealing diabetic foot ulcers. Diabetes Care. 2001;24(2):290-5.

[26] Falanga V, Margolis D, Alvarez O, et al. Rapid healing of venous ulcers and lack of clinical rejection with an allogeneic cultured human skin equivalent. Arch Dermatol. 1998;134(3):293-300.

[27] Eaglstein WH, Falanga V. Tissue engineering and the development of Apligraf, a human skin equivalent. Clin Ther. 1997;19(5):894-905.

[28] Kirsner RS, Marston WA, Snyder RJ, Lee TD, Cargill DI, Slade HB. Clinical experience and best practices using living skin equivalents. Int Wound J. 2012;9 Suppl 1:1-25.

[29] Lane JE, Tyagi SC. Stem cells in the treatment of wound healing. Int J Clin Exp Pathol. 2009;2(6):582-90.

[30] Fernández-Gutiérrez M, Salvador-Rodríguez L, Sánchez-García A, et al. Bioengineered skin substitutes: clinical applications and future perspectives. Cells. 2021;10(7):1743.