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Review

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Exploring the potential of dermal grafting: a narrative review in plastic surgery

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Abstract

Dermal grafting (DG) has emerged as an innovative technique in plastic and reconstructive surgery, offering several advantages over traditional skin grafting methods. This review provides an in-depth exploration of DG, highlighting its applications, benefits, and future directions. The historical evolution of skin grafting is discussed, tracing the development of DG as a novel approach to address the limitations of conventional techniques.

The review focuses on four key advantages of DG: (1) accelerated healing of donor sites; (2) improved aesthetic outcomes at recipient sites due to the elastic nature of dermal grafts; (3) increased graft availability by effectively at least doubling the amount of graft material obtained from a single donor site; and (4) utility in scar revision and reconstruction procedures, particularly in areas with restrictive scarring or contractures.

Recent advancements, such as the development of a multiblade dermatome, have addressed the technical challenges associated with DG harvesting, potentially broadening the clinical adoption of this technique. Preliminary results from studies utilizing this new device have demonstrated its feasibility in producing dual grafts (split-thickness skin graft and dermal graft) concurrently, simplifying the surgical procedure.

The review also explores future directions in DG, including further refinements to the multiblade dermatome, and clinical trials to validate long-term benefits.

Overall, this review highlights the significant advantages of DG and its potential in advancements of plastic and reconstructive surgery, ultimately improving patient outcomes and quality of life.

Keywords: Burns, donor sites, scarring, skin defects, split thickness skin grafting, surgery

INTRODUCTION

Skin grafting is an essential and extensively utilized reconstructive method for addressing skin defects, regardless of their cause or anatomical location. Among the various free grafts used in reconstructive surgery, such as split-thickness skin grafts (STSGs), full-thickness skin grafts (FTSGs), and composite grafts, STSGs are the most frequently employed and have the broadest application in routine surgical practice[1,2].

An STSG is defined as a free tissue transfer deliberately separated from a donor site and transplanted to a recipient site, where the graft relies on capillary ingrowth for survival. While the concept of skin grafting is ancient, the modern STSG technique was first described in the 1872-ties by Ollier[3] and Reverdin[4]. Remarkably, this procedure has remained largely unchanged for 150 years[2,3,4].

Despite its widespread use, the STSG technique has notable limitations, including donor site morbidity and recipient site scarring[5]. This is especially problematic in burn management, where scar contracture and the characteristic mesh or MEEK patterns post-transplantation contribute to suboptimal healing and scarring[2].

Meshing or the MEEK procedure is typically performed to extend the graft over a larger area, as STSGs are inelastic. However, for facial regions, STSGs are left unmeshed to avoid the unattractive mesh pattern and reduce scarring. An unmeshed STSG, or sheet graft, improves scar quality but requires a larger donor site[2].

An alternative technique involves using only the dermis portion as a graft. This approach harvests skin in two layers from the same site: a traditional STSG of the upper layer and a dermal graft (DG) of the lower layer. The upper part is returned to the donor site, while the dermal portion is grafted to the recipient site[2]. This method has gained attention for its potential to reduce issues at both donor and recipient sites, with the DG's elasticity potentially reducing the need for meshing or the use of the MEEK technique at the recipient site[2,6-9]. Furthermore, it needs to be emphasized that the dermal graft re-epithelializes from the epidermal appendages included in the dermal graft and no STSG is needed for wound closure.

HISTORICAL ASPECTS OF DERMAL GRAFTING

The initial idea of using a separate dermal component in STSG procedures was introduced by Hynes in 1954 as an alternative to conventional flap techniques[2,10]. Following this, two publications described a modified technique where the DG was inverted at the recipient site, allowing it to vascularize before a secondary STSG was applied after two weeks[2,7].

Tanabe *et al.* used dermal grafting to reconstruct palmar skin defects, achieving a 99.1% graft take rate with excellent aesthetic results and no scarring[9]. In this method, the STSG was harvested first, followed by the dermis graft, which healed at the recipient site without scarring within 7-8 days[2].

Querings *et al.*[11] reported favorable functional and aesthetic outcomes with dermal grafting[2]. An experimental study by Rubis *et al.*[8] using a porcine model showed slower epithelialization at the dermal recipient site but achieved complete healing within two weeks[2].

Kogan *et al.*[12] studied eight patients and found good dermal graft take rates at the recipient site[2]. Han *et al.*[6] conducted the largest study, comparing dermal grafting to STSG, and found less severe scarring at the recipient site with the dermal graft technique[2].

Kang *et al.*[13] demonstrated successful dermal graft application over exposed bone and tendons in a small case series[2]. These findings align with the results of a study conducted by Lindford *et al.*[14]. In this study, 16 dermal grafts performed on nine patients were compared to regular STSG. The time to epithelialization of the dermal grafts at the recipient sites ranged from 12 to 35 days (median 21 days), with all grafts achieving > 90% epithelialization by 4 weeks. There was no significant difference in donor site healing times between the DG "deeper" donor site (range 7-35 days, mean 16.1 days) and the conventional STSG donor site (range 7-35 days, mean 16.7 days). The donor sites were located on the backs of the patients[2].

Han *et al.* conducted a retrospective study showing satisfactory aesthetic and functional outcomes when using dermal grafts to cover small skin defects on the face after tumor resection[15]. Most patients had high-quality skin characteristics and excellent satisfaction with the dermal grafts for both functional and aesthetic results at the recipient sites[2]. A recent dual-center, international study ["Trial registration: ClinicalTrials.gov Identifier (NCT05189743) 12/01/2022"] by Dogan *et al.*[2] highlighted reduced donor site morbidity and favorable long-term recipient site outcomes with dermal grafting, owing to its elasticity and reduced need for meshing[2].

TECHNICAL ASPECTS

The dermal grafting technique represents a novel approach, and there is currently no established instrument specifically designed for DG harvesting. In short, regular DG harvesting involves first taking a regular STSG followed by harvesting a second graft from the same skin area with high precision, ensuring it is of the same size; the second skin strip is the DG. Consequently, significant training is required to achieve satisfactory graft yields using a conventional dermatome, which resulted in the limited sample sizes in the present studies[2]. We also believe this may explain why the technique has not been further explored in previous attempts, and why most of the evidence presented in this review regarding the DG technique is based on small patient series. The process of obtaining a DG is significantly more technically demanding compared to the conventional STSG harvest. While the first layer, the STSG, is typically managed with relative ease by a trained plastic surgeon, the harvesting of the second layer, the DG, poses significant challenges. These challenges can be summarized as follows[2]:

1. Lack of tissue firmness: The dermal tissue exhibits less firmness compared to the epidermis, making it difficult to ascertain the precise thickness of the graft during harvesting when addressing the skin the second time with the dermatome.

2. Precise border alignment: To obtain a proper DG, the second harvesting procedure needs to be meticulously adjusted to align with the first, as the four borders of the previously harvested STSG need to be in precise alignment to avoid obtaining a deranged dermal graft, as the dermatome is tilted between uncut skin and the wound of the previous graft.

These challenges have hindered the implementation of the technique despite its evident advantages.

ADVANTAGES OF DERMAL GRAFTING IN PLASTIC AND RECONSTRUCTIVE SURGERY

Increased healing rate of donor sites

Dermal grafting has been shown to accelerate the healing process at donor sites compared to traditional STSG. By harvesting both a STSG and a DG from the same donor site, and returning the STGS back to the donor site, the donor site morbidity is minimized and recovery is faster and cosmetically better. This technique minimizes donor site morbidity and promotes faster recovery. This dual-harvesting approach not only enhances healing but also reduces the overall impact on the patient.

Improved aesthetic outcomes

One of the significant advantages of dermal grafts is their elasticity, which allows for better aesthetic outcomes. Unlike meshed grafts, which leave a characteristic mesh pattern when expanded, dermal grafts can be applied without meshing, resulting in a smoother and more natural appearance at the recipient site. This is particularly beneficial in areas where aesthetics is crucial, such as the face and hands. Additionally, the risk of secondary contracture is lower compared to that of regular STSGs, highlighting the significance of dermal grafts in covering body areas with a higher risk of contractures, such as big joints and the neck region.

Increased graft availability

Dermal grafting effectively doubles or triples the amount of graft material available from a single donor site. By obtaining both a STSG and a DG simultaneously, surgeons can maximize the use of available donor sites, reducing the need for additional donor areas and minimizing associated morbidity. This increased availability is especially advantageous in cases involving extensive burns or large wound areas.

Utility in scar revision and reconstruction

Dermal grafts are particularly useful in the reconstruction of areas with restrictive scars or contractures. The elastic nature of dermal grafts allows for improved mobility and range of motion in scarred areas, potentially reducing the need for more extensive surgical interventions. Additionally, dermal grafts can be combined with other reconstructive techniques, such as tissue expansion or flap procedures, to enhance both aesthetic and functional outcomes.

In conclusion, dermal grafting represents a significant advancement in plastic and reconstructive surgery, offering numerous potential benefits over traditional skin grafting methods. Its ability to accelerate donor site healing, improve aesthetic outcomes at the recipient site, increase graft availability, and facilitate scar revision and reconstruction makes it a valuable technique for modern surgical practice. However, one limitation is that the above-mentioned advantages of the DG technique are currently supported by only smaller case series, and further evidence is needed. Additionally, the technique requires refinement through larger patient studies. As innovations such as the multiblade dermatome continue to evolve, the accessibility and practicality of dermal grafting are expected to improve, further expanding its clinical applications.

PRELIMINARY RESULTS WITH A NEW MULTIBLADE DERMATOME AND FUTURE WORK

Recent advancements in dermal grafting technology have led to the development of a multiblade dermatome, designed to address the technical challenges associated with harvesting dermal grafts using traditional single-blade dermatomes. The study presented below describes the development and initial application of a novel multiblade dermatome, designed to concurrently harvest a conventional STSG and a DG within a single surgical procedure. Traditional methods of DG extraction have faced significant technical challenges, limiting their clinical adoption. However, this new prototype aims to overcome these obstacles, potentially broadening the usage of dermal grafting techniques.

Initial experiments with this device [Figure 1] (Patent, Reg. 2050787-7 and 21739981.5) on four human cadavers demonstrated its capability to produce at least two distinct grafts with predetermined thicknesses, simplifying what has typically been a complex and demanding surgical task. The thickness of the dermal graft can be adjusted within the desired range by modifying the opening at the second cutting blade. As shown in the paper, this adjustment enables the production of dermal grafts with thicknesses ranging from 200 to 1,000 μm. At the microscopic level, the uniformity of both the upper and lower grafts confirmed the precision of the dermatome, and the ease of use was documented in parallel and thus supported its future potential. This proof-of-concept study highlights the multiblade dermatome's feasibility in producing dual grafts, suggesting a future where dermal grafting could be more accessible and practical in clinical settings[15].

Preliminary results utilizing this new device are promising. The multiblade dermatome allows for more precise and consistent cuts, significantly reducing the technical difficulty of the procedure. This innovation not only simplifies the harvesting process but also enhances the quality of the dermal grafts obtained, leading to better integration and healing at the recipient site.

FUTURE WORK

One challenge that needs further exploration is the expansion level of the DG and its relationship with the healing process. Another topic of interest is the choice of thickness for the DG component, where two issues evolve. Firstly, there is a need for a thicker dermal component in the reconstruction of areas with restrictive scars or contractures. Secondly, the multiblade dermatome can be adjusted to take different thicknesses of the graft, and the choice of thickness needs to be explored, also from the point of creating a full-thickness skin defect. The variability of the dermal component thickness needs to be included in the decision process, as different body areas, such as the back, limb, and sole, provide dermal areas with varying thicknesses. Additionally, the value of generating more than two strips with a multiblade dermatome needs to be further explored.

Future work will also focus on further refining the multiblade dermatome to optimize its performance and ease of use. Additionally, clinical trials are needed to validate the long-term benefits of using this device in various reconstructive procedures. Researchers are also exploring the potential for combining the multiblade dermatome with other advanced technologies, such as tissue engineering, to further enhance the precision and efficiency of dermal grafting. These efforts aim to make dermal grafting more accessible and practical for a wider range of clinical applications, ultimately improving patient outcomes in plastic and reconstructive surgery.

SUMMARY

The review traces the historical development of skin grafting, leading to the introduction of dermal grafting in the early 21st century as a novel approach to overcome the limitations of conventional techniques. Four main advantages of dermal grafting are highlighted:

Accelerated healing at donor sites compared to conventional split-thickness grafts.

Improved aesthetic outcomes due to the elastic nature of dermal grafts, enabling application without meshing for a smoother appearance.

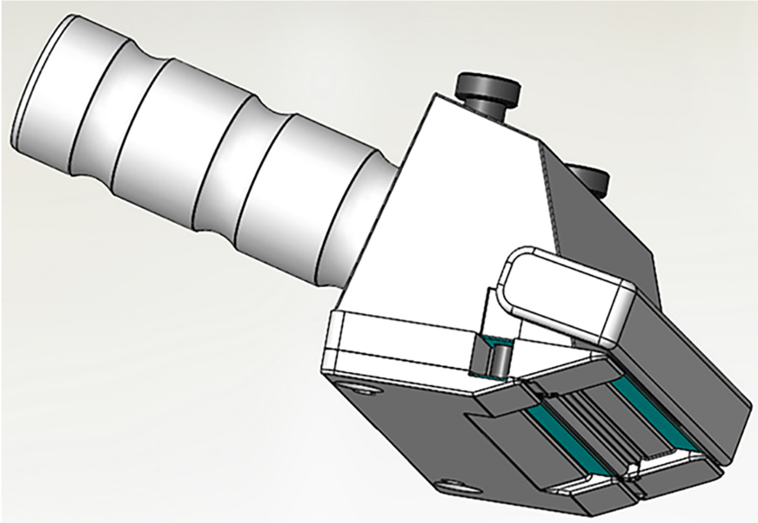

Figure 1. The first prototype of a multi, e.g., double-blade dermatome. The two blades and the opening for tissue transfer are marked in green.

Increased graft availability by effectively at least doubling the material from a single donor site, when using a double-blade dermatome as compared to a singleblade one.

Utility in the reconstruction of areas with restrictive scars or contractures.

Recent innovations like the multiblade dermatome have addressed technical challenges in harvesting dermal grafts, potentially broadening clinical adoption. Initial studies demonstrate the feasibility of this device in concurrently producing split-thickness and dermal grafts, significantly simplifying the surgical procedure.

Key areas of future work include optimizing the multiblade dermatome, exploring expansion levels and thickness variability of dermal grafts, conducting large clinical trials to validate long-term benefits, and combining dermal grafting with advanced technologies for tissue regeneration.

Overall, this review highlights dermal grafting's significant advantages and potential to revolutionize plastic and reconstructive surgery, ultimately improving patient outcomes and quality of life.

DECLARATIONS

Authors' contributions

Review design and drafting of the initial manuscript: Sjöberg F, Dogan S

Revising it and contributing with important intellectual content: Sjöberg F, Dogan S, El-Serafi AT, Sjöberg Z, Abdelrahman I, Steinvall I, Karlsson M, Olofsson P, Lindford A, Vuola J, Elmasry M

All authors had complete access to the data that support this publication and approved the final article for submission

All authors contributed substantially to the concept formation of this review manuscript

Availability of data and materials

Data and materials are available in the manuscript.

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Conflicts of interest

Sjöberg F and Sjöberg Z have received consultancy fees from De Soutter Medical Ltd., which owns the patent described in this manuscript, Patent, Reg. (2050787-7) and (21739981.5).

Ethical approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

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