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Review Article

Safety and effectiveness of micropigmentation skin grafting using the Meek method

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Abstract: The management of complex burn injuries has evolved significantly, with various surgical techniques developed to improve outcomes. This review examines the evolution of these methods, focusing particularly on mesh grafting and the Meek technique. While mesh grafting is effective, it poses challenges such as limited graft coverage and a high demand for autologous skin. In contrast, the Meek technique, a specialized method reintroduced in 1993, offers notable advantages for extensive burns by achieving higher skin expansion ratios of up to 1:9 and reducing the need for large donor sites. The Meek technique uses a meshing device to create tiny perforations in small skin grafts, facilitating their expansion to cover larger wound areas and improving healing outcomes. Recent studies highlight its effectiveness across various burn severities and age groups, especially when combined with Cultured Epithelial Autografts (CEA). Additionally, bioengineering advancements like Biobrane offer temporary skin substitutes to aid burn wound healing in pediatric cases, though they ultimately require replacement with autografts. While the Meek technique presents certain challenges, such as a 6-day delay before applying allografts, it remains a robust alternative to traditional methods. Clinical experience indicates that the Meek technique, particularly when combined with CEA, can achieve superior results for severe burns compared to conventional mesh grafting. This review emphasizes the Meek technique's potential as a valuable tool in burn wound management, offering a promising approach for improving patient outcomes in complex burn injuries.

Keywords: Meek technique, burns, mesh method

Introduction

In recent decades, there has been a notable evolution in surgical approaches aimed at managing complex burn injuries. Various methodologies have been proposed, including stamp skin grafting, mesh grafting, composite autografts and homografts, interval self-expanding mesh and homografts, microskin grafting, and the Meek technique. Each method presents a unique set of advantages and drawbacks [1].

The Meek technique is a specialized method used in dermatology and plastic surgery for skin grafting, particularly in the treatment of extensive burn injuries [2]. It involves expanding small pieces of skin to cover larger areas, significantly increasing coverage from a limited donor site [3]. The process utilizes a meshing device that creates multiple tiny perforations in the graft, enabling it to stretch and cover a larger wound area. This approach enhances healing, reduces the need for extensive donor sites, and improves overall outcomes for patients with severe skin loss [4].

Additionally, bioengineering coatings like Biobrane have been utilized as temporary skin substitutes to expedite the healing process of burn wounds in pediatric patients. While this approach reduces the risk of infection, it ultimately necessitates replacement with autografts. In cases of extensive burns, perforated skin grafts are used to cover large areas of affected regions. However, when skin expansion ratios exceed 1:4, organizing the mesh graft becomes more challenging, potentially resulting in an aesthetically displeasing appearance over the long term due to leaving parts of the wounds uncovered within the mesh intervals [5, 6].

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The advent of grafts derived from cultured epithelial cells, first proposed by Reinwald and Green in 1975, marked a significant advancement in burn treatment. While early reports were promising, data on its efficacy in burn surgery remained largely limited to pediatric cases [7]. Another innovative approach, the Meek technique, introduced by Meek in 1958, greatly enhances skin extensibility, achieving expansion ratios of up to 1:9. This technique uses small skin grafts and preformed dressings to ensure the regular expansion of square-shaped segments within the graft [8].

The Meek method, which had initially fallen out of favor with the emergence of meshed split-thickness skin grafts in 1960, experienced a resurgence in 1993 when reintroduced by Chris and colleagues. The Meek technique has been considered superior to mesh grafting due to its higher skin expansion rates in adult patients with major burns [9, 10]. Since 1993, it has been used in conjunction with Cultured Epithelial Autografts (CEA) to expedite burn wound healing. This study aims to evaluate the evidence regarding the safety and efficacy of the Meek technique across different burn severity levels and age groups, offering valuable insights into its clinical utility.

Method

Study design

A comprehensive literature review was conducted to delve into the management of population of burn patients treated with micro skin grafting, which were compared with other skin grafting methods in terms of healing rate and wound management. The study was conducted in alignment with the PRISMA criteria (Preferred Reporting Items for Systematic Reviews and Meta-Analyses).

Search strategy

The investigation encompassed various databases including PubMed, MEDLINE, Scopus, Web of Science, Directory of Open Access Journals (DOAJ), Science Direct, and Google Scholar, spanning the timeframe between January 2016 and May 2022. Employing the Advanced Search Builder, specific keywords were targeted within the [Title OR Abstract] of the articles. To maintain consistency, only research articles published in the English language were considered. The search terms employed were '(burn OR graft) and (meek OR micrograft OR skin grafting)'. The inclusion criteria for articles were conducted on burn patients that underwent Meek grafts at least in one arm. We excluded studies that focused on samples primarily composed of patients under the age of 18, studies with fewer than 10 participants, and studies lacking original data.

Moreover, relevant studies were incorporated based on an examination of the references provided within previously published review articles. A total of 6 finalized research articles and one preprint paper were identified as meeting the eligibility criteria. In some instances, only key findings that directly aligned with the focus of this review were selected for inclusion.

In selected articles, authors evaluate safety and efficacy using several key indexes and parameters. These include morbidity and mortality rates, which assess the incidence of complications and fatalities, respectively. Adverse events and side effects are also closely monitored to determine safety. Efficacy is often measured through clinical outcomes such as the success rate of the intervention, improvement in specific health metrics, and patient-reported outcomes like quality of life and satisfaction. Additionally, parameters such as recovery time and the duration of hospital stay provide insights into both safety and the practical effectiveness of the treatment.

Findings

Included studies

In the first stage, 1421 articles were obtained. Repetitive and unrelated articles were removed, and the full text of the articles obtained from the previous stage was examined based on the entry and exit criteria determined by the researchers. Finally, based on compliance with these criteria, 6 articles entered the final phase of the study. **Table 1** shows the summary of the results of these 6 studies.

Explanation of results

A study by Carey and colleagues focused on a 65-year-old patient who sustained 40% deep skin burns after falling into hot bath water dur-

Table 1. Summary of the previous 6 studies, evaluating micropigmentation skin grafting

Author	Country	Year	Intervention	Comparison	Study design	Patient samples	Follow up	Results
Chris and colleagues	Netherlands	1994	Meek technique	Mesh	RCT	A 65-year-old male patient with 40% deep burns.	10 months	In cases where the expansion coefficient is more than 1:6, the Meek method is superior to the mesh.
Larry and colleagues	Kuwait	1998-1999	Modified Meek technique with skin expansion coefficient 1:4, 1:6 and 1:9	Common Treatment Methods	RCT	A patient with severe burns with an average age of 24 years (age range 13-42 years) (4 females, 3 males).	70 days	This method is the method of choice in patients with severe burns who do not have external skin graft donation sites.
Sieh and colleagues	Taiwan and Texas	2000-2004	Meek technique	Common Treatment Methods	RCT	37 patients with third-degree burns, where more than 40% of their bodies are burned.	5 years	This technique is strongly recommended for consideration in the management of extensive burns.
Menon and colleagues	Australia	2004-2011	Meek	SSG+CE A (mesh)	Retrospective Cohort	7 patients with burns, with an average age of 2-12 years.	7 years	Meek technique in combination with CEA method seems to be a useful additional option in manual wound closure in severely burned pediatric patients.
J. Cook and colleagues	Canada	-	Meek Micrograft	Common Treatment Methods	Case study	Two patients suffering from severe burns.	-	Using this technique can help achieve permanent coverage for large burn wounds.
Vital Lawn Rajesh Shah	India	2010	Meek Micrograft	Common Treatment Methods	Cohort	868 patients suffering from severe burns.	8 years	After using this technique, the quality and color of the skin has shown great improvement, and due to less antibiotic consumption and also the reduction of the infection caused by its use, the use of this technique will be cost-effective.

RCT: Randomized Clinical Trial, SSG: split-thickness skin graft, CEA: Cultured Epithelial Autografts.

ing an epileptic seizure. The study aimed to compare mesh grafts and the Meek technique (sandwich technique), with a follow-up period of 10 months. The primary advantage of the mesh method was its ease of use and reduced operation time. However, an expansion ratio greater than 1:4 left the grafts susceptible to dry skin, potentially leading to complications. While xenoskin grafts generally improved wound bed protection, an expansion ratio greater than 1:6 was considered impractical. This was due to the challenging manipulation of long autograft strips, which is typically unfeasible for patients with extensive injuries [4].

The lack of transparency between the theoretical expansion coefficient and the actual expansion coefficient was observed with mesh connections, as proven in previous studies. The coefficients of expansion refer to the ability of materials to change size in response to changes in temperature. The theoretical coefficient of expansion is a calculated value based on a material's physical and chemical properties. It predicts how much a material will expand or contract with each degree of temperature change. For solids, the linear coefficient of expansion (α) is commonly used and is expressed in units such as per degree Celsius ($°C^{-1}$) or per degree Fahrenheit ($°F^{-1}$). For fluids and gases, the volumetric coefficient of expansion (β) is used, relating to the change in volume per degree of temperature change.

The limitation of grafting with the mesh method led to an approach towards the technique of smaller skin grafts. Small pieces of skin were cut in a circle with the help of a knife or scissors, and sometimes they were extended by keeping them in bandages on the surface of skin wounds with or without allogeneic or xenogeneic skin grafts. Despite the uncontrolled distribution and orientation of epidermal components, the reported results were consistent with previous studies, with an expansion coefficient greater than 1:12 [11, 12].

Application of Meek technique

Although the study stated that the practical application of this relatively complex method has not yet been proven, the Meek technique uses pre-complicated dressings to provide regular distribution and correct orientation of the external graft areas of the lower skin. One of the drawbacks of this method is that the allograft can only be used after a 6-day delay, allowing the areas to grow properly before removing the dressings. However, no significant delay was found in the results of this study [13]. The clinical experiences of the collaborators of this study highlight additional benefits of the Meek method for granulated wounds and wounds of poor quality. Although the self-bonding regions are not mutually connected, the failure of the graft in one area does not necessarily affect the overall perception of the graft. In contrast, with the mesh method, separation from a small area of the graft can lead to large separations and rejection of the graft during dressing changes. An interesting point about the Meek technique is its effectiveness under relatively unfavorable conditions, as noted in the Ben Mayer report. This enables the use of different types of external link posts compared to the mesh method under these conditions [14].

Early skin graft surgery

In the study by Abdul Redalari and his colleagues, early skin graft surgery using the modified Meek method was performed on 7 patients with severe burns, with an average age of 24 years. The division of wound skin for grafting using the mesh method is considered an accepted treatment for patients with severe burns in most burn centers [15]. Although the lack of external skin graft was a problem after the initial surgery, this limitation could lead to wound infection and septicemia, potentially resulting in death. The initial experience of the collaborators in using the Meek technique in a patient with severe burns indicates that this technique has been developed as a reliable method to achieve wound healing with autografts [15].

Discussion

Meek's method, as reported by other researchers, allows for greater skin expansion compared to the mesh method. Small internal grafts protected by dressing pieces are more effective than the mesh method. The chances of removing the small pieces of autograft during dressing changes are negligible. By the seventh day, when the polyamide gauze is removed, the autograft parts have grown sufficiently within the fabric. The researchers of this study found that the spacing and distribution of small grafts

allow for faster and more uniform epithelialization, a benefit previously observed by other researchers. Even if the wound becomes infected, the possibility of graft rejection is usually limited to that particular area.

Although initially the self-grafted areas were covered with mesh grafts using the mesh technique with a skin expansion coefficient of 1:4, similar grafts were applied until the seventh day after the operation [2, 16]. After the first patient, it was concluded that overall coverage with similar grafts is not necessary for the advancement of the epithelialization process from the edges of the self-grafted areas. In the last patient, the polyamide gauze piece was removed after 10 days of surgery without complications [3]. However, the skin expansion graft required more total coverage with a similar graft to prevent infection and promote faster skin epithelization. This method was changed even earlier by others in the technique of combining internal and similar grafts.

A study by Sheng Sieh and colleagues, conducted with a 5-year follow-up period, demonstrated a further decrease in mortality through early debridement and rapid wound covering with autologous skin grafts. While removing dead skin and covering wounds with the patient's own skin may be feasible initially if the burn area is small, significant blood loss and difficulty in wound coverage often pose major obstacles for individuals with extensive burns. To address this, the researchers proposed a sectional approach to wound debridement based on body topography. They arbitrarily divided the body surface into six parts: head and neck, anterior trunk, posterior trunk, right and left upper limbs, and right and left lower limbs [17].

Researchers found that the skin grafting process is often hindered due to limited skin donor sites, so using small graft pieces, known as the postage stamp technique, may be supportive [18]. Although this method was primarily designed to enhance graft flexibility, cadaveric skin grafts have often been effective among the various biological coverings used for wound coverage, especially if the areas require grafting with similar skin components (micrografts). In practice, xenographic materials such as fresh or treated pig skin were used, and no clinical or technical problems related to the involvement of pig skin were observed [13].

In their study, Sieh and colleagues observed that the resurfacing of a heavily infected wound covered using the Meek method with a skin expansion ratio of 1:6 is feasible. Although the combination of the Meek technique with other methods, such as allografts or cultured autografts, has been supported for enhancing skin regeneration in wounds with expansion ratios of 1:6 or 1:9, they did not employ these additional techniques. Instead, they followed the described regimen including antibiotic ointment and gauze dressing soaked in paraffin in daily changes. Completion of resurfacing was observed in 7 to 10 days in people who used a skin expansion coefficient of 1:4, 2 to 3 weeks in people with a skin expansion coefficient of 1:6, and 1 month with a skin expansion coefficient of 1:9 [19].

While complications like wound contraction and hypertrophic scar formation were evident in a small number of patients, the authors concluded that their experience with the modified Meek Micrograft method indicates that it is an effective and valuable technique for covering extensive burns, especially when skin donor areas are limited. They strongly advocate for the use of this method in the management of extensive burn injuries [20].

Menon and her colleagues investigated the Meek method for the management of children's burns and used a combination of the Meek method and CEA. They found in their study that although the common split-thickness skin graft (SSG) method may be used with an expansion ratio of 1:4 and higher to cover extensive areas, such large volumes for SSG pose a challenge for managing and healing burn wounds in crevices and fissures (burn interspaces) that necessarily do not come under coverage. They found that by using the modified mesh method once, its benefits are more than the common mesh method (SSG) for children with major burns: 1) The grafting was done with this method on the person's back because it was easy to manipulate. 2) The expansion ratio could be adjusted proportionally or even after mesh grafting, allowing flexibility as the grafting process progresses. 3) The modified mesh method allowed expansion ratios greater than 1:9 compared to the conventional mesh method. 4) In affected

children with a limited donor site, even small pieces of SSG that may have been wasted using conventional methods may have a more successful graft with micrograft [21].

The experience of this study, with excellent harvest and relatively low rate of infection, was consistent with the experiences of other surgeons in adult burns. Normally, burn wounds in adults may heal 90% during the period of 3 to 5 weeks after a large surface burn. This pointed to the specific role of the modified Meek technique in burn patients following a delay in the presentation or transfer of the patient, developed infection, and a potential reduction in the reduction of graft rejection as a result of infection in comparison with conventional techniques [12].

Although the costs associated with the unique dermatome, mesher, and disposable supplies and materials must be considered, these expenses might be offset by the savings achieved through improved grafting outcomes and faster discharge for very complex cases of major burns. Initially introduced as a skin substitute for severe burn patients, CEA encountered several application issues, including challenges in handling and transportation and fragility of the graft bond. Additionally, it takes about 4 weeks from the time of skin sampling to grow the grafts [10].

Subsequently, the use of a CEA suspension system with mesh autograft is presented in the form of a spray, which can generally be provided within two weeks and provides a more appropriate role for CEA in relation to mesh autograft [4]. CEA has been successfully used with SSG in both children and adults, and at least in adults with major burns treated with a modified Meek technique. The experiences of this study in using the combination of these two methods were generally positive, with the average culture time reported as 17 days, and the rate of epithelialization was reported to be 95% during 4 weeks with an average length of stay (LOS) of 51 days [5].

In addition, no cases of blisters or scar contractions were observed in the treated areas with both the modified Meek and CEA methods. The small sample size in this study, together with the difference in the injury mechanism and the grafted sites, prevents an objective comparison between the conventional graft and the modified Meek technique versus the usual CEA with the modified Meek techniques. The preliminary results of this study suggest that future studies involving several pediatric burn centers may be helpful in defining the differences in achieving burn wound healing in children with major burns.

Meek grafts offer a technically straightforward approach with minimal wound care requirements. However, performing small mesh grafts can pose challenges, especially considering the limited availability of skin donor sites.

Increasing the skin expansion ratio beyond 1:6 can hinder the success of grafting, rendering the process labor-intensive and making wound coverage less predictable. While Meek grafts differ from mesh grafting in their mechanical precision, they also incur relatively high costs and labor intensity. In terms of infection, it's noted that graft failure is commonly caused by infections. Interestingly, postage stamp-sized skin grafts appear more resistant to microbial invasion compared to larger grafts, such as those created with mesh techniques [22]. Combining Meek autografts with CEA in spray form shows promise in promoting burn wound healing without causing contractions, although Hypertrophic Scarring (HTS) remains a clinical concern [9].

The Meek technique, particularly when combined with CEA, emerges as a valuable option for achieving wound closure in severely burned patients, including pediatric cases. Overall, Meek grafting demonstrates comparable efficacy to extensive mesh grafts, yielding satisfactory functional and aesthetic outcomes in most cases [6]. Initial experiences suggest that Meek grafts are particularly beneficial for patients with severe burns lacking external skin graft donation sites. Observations also advocate for expanding the use of mesh techniques in deep burns where complete initial debridement may not be feasible. In such scenarios, row debridement coupled with Meek application in areas with granulation tissue has shown effectiveness [15]. Notably, the Meek technique is applicable across age groups, with its efficacy peaking between ages 6 and 65. Additionally, Meek grafts exhibit a lower rejection rate and are particularly effective for exten-

sive burns in terms of both surface area and depth.

In this literature review, we did not perform statistical analysis, which is a limitation of our study. As our objective was to summarize and evaluate the evolution of surgical techniques in burn management, we relied on previously published data. Future research involving meta-analyses or original studies with statistical comparisons could provide deeper insights into the efficacy of these techniques.

Conclusion

In the present study, we offered a comprehensive review of surgical techniques for managing complex burn injuries, with a focus on mesh grafting and the Meek technique. While mesh grafting is a simple method, it requires substantial skin and can result in less efficient graft distribution. In contrast, the Meek technique, which allows for superior skin expansion rates, has been reintroduced as an effective option, especially when combined with Cultured Epithelial Autografts (CEA). Studies underscore its efficacy across various burn severities and age groups, providing valuable insights into its clinical effectiveness. Ultimately, the Meek technique emerges as a promising method for achieving wound closure in severe burn cases, with the potential for better outcomes compared to traditional approaches.

Disclosure of conflict of interest

None.

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