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Role of Functional Regenerative Trilaminar Scaffold Dressing in Wound Bed Preparation

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Abstract

Advancements in wound healing have incorporated tissue regeneration therapy as a crucial tool for managing both acute and chronic wounds. Bio constructs designed to facilitate wound regeneration utilize natural, artificial, or hybrid materials, collectively referred to as regeneration scaffolds. The components of regeneration scaffolds play a crucial role in enhancing the skin's natural self-renewal abilities and accelerating the healing process. These scaffolds are designed to provide essential growth factors and stem cells that stimulate cell proliferation and tissue repair. By creating an optimal environment for cellular activities, they help in quicker wound healing and tissue regeneration, leading to improved recovery outcomes. This advanced approach not only supports the body's inherent healing mechanisms but also ensures more efficient and effective restoration of damaged skin. Scaffolds have played crucial roles in diverse medical and research contexts over an extended period. However, commercially available scaffolds are often prohibitively expensive, limiting their accessibility. To address this issue, an indigenous scaffold was developed using a combination of multiple components, including the amniotic membrane, collagen, and silicone. This new method aimed to produce a more affordable option without sacrificing standards of excellence. Through rigorous testing and evaluation, it was found that this indigenous scaffold performed on par with, and in some cases even surpassed, the commercially available options in terms of functionality and efficacy. This development not only offers a more affordable solution but also paves the way for wider use in medical and scientific fields.

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Keywords: Regeneration scaffold; post burn raw area; dermal regeneration; regenerative therapy, indigenous scaffold, silicone, medical field

INTRODUCTION

According to the World Health Organization (WHO), thermal burn injuries result in more than 300,000 deaths globally each year. Millions are suffering from the physical and emotional consequences of burns [1]. 6.5 million individuals suffer from chronic skin ulcers caused by prolonged pressure, venous stasis, or diabetes mellitus [2]. Regeneration therapy is a good option that can be considered in the management of wounds. Regeneration of wounds is done by stimulating the innate ability of the skin for self-renewal. The gradual understanding of the biological processes of wound healing has led to the development of biological constructs that actively promote tissue regeneration using regeneration platforms, or scaffolds, as well as the incorporation of cell-signaling elements such as Growth Factors and Stem Cells [3]. However the commercially available Regeneration scaffolds are very expensive, the cost may range between Rs. 20000 to Rs 30000. Hence, we decided to make an indigenous regenerative scaffold using the materials available in the ward. In this article, we share our experience of making a regenerative scaffold with three layers in the management of a post-burn raw area patient [4].

MATERIALS AND METHODS

This study took place in the Plastic Surgery Department of a tertiary care center following approval from the department's ethical committee. Written consent was obtained from the patients involved. Figure 1 The details of the patient in the study are as follows: A 1 year 9-month-old female was admitted with a history of thermal flame burns involving 3% TBSA second-degree superficial. The burns involved bilateral feet. After the initial fluid resuscitation, she was initially managed with dry collagen heterografting, and later the dry collagen was replaced with a 3-layer regeneration scaffold. The regeneration scaffold was assembled within the Plastic Surgery Department using materials already on hand.

Three consecutive days of trilaminar scaffold dressing was done, following which SSG from allograft donor was applied [5].

The four layers from outer to inner are as follows:

1. Silicone
2. Collagen
3. Amniotic membrane

The description of each layer is as follows (Figure 2-5)

A self-adhesive collagen sheet.

The amniotic membrane was obtained from the Obstetrics Department of the institution. It was collected from a healthy woman with an uneventful pregnancy, who underwent screening for Hepatitis B and C, HIV 1 and 2, and VDRL after a normal vaginal delivery. Following collection, the membrane was rinsed with saline, treated with Heparin, antimicrobial agents, antifungals, and preserved in glycerol under refrigeration [6-8].

Figure 1. Raw area bilateral feet.

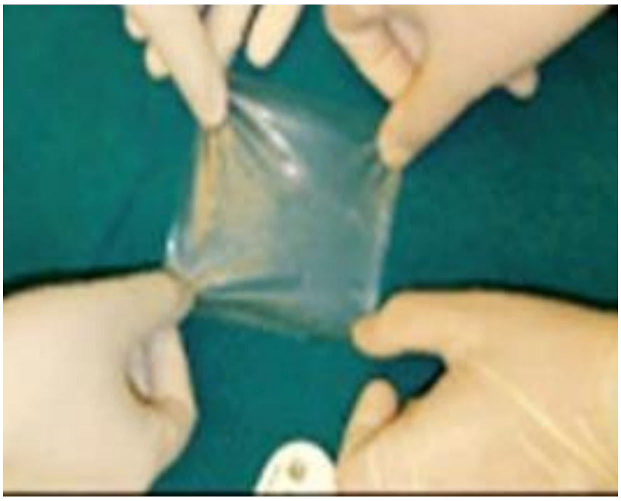

Figure 2. Silicone Sheet.

Figure 3. Collagen sheet.

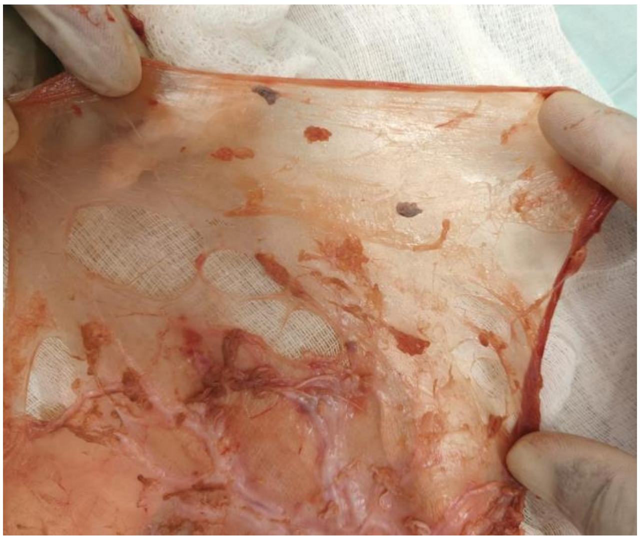

Figure 4. Amniotic membrane.

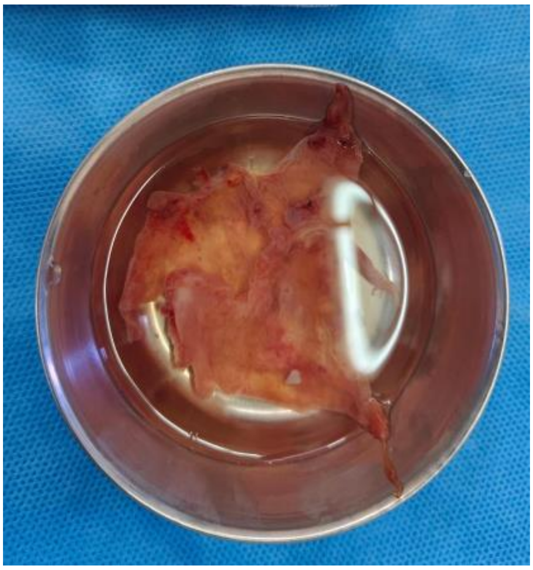
Figure 5. Harvesting of amniotic membrane.

RESULT

The three-layer regeneration scaffold successfully promotes wound regeneration after flame burns

The length of hospital stay was almost identical to patients who underwent allografting. No complications were noted during the study.

DISCUSSION

Thermal wounds have been divided into three zones by Jackson; Zone of coagulation, Zone of stasis

The zone of hyperemia is a critical area in burn injuries, characterized by increased blood flow due to inflammation. If not managed properly, factors such as inadequate fluid resuscitation, wound infection, or poor perfusion can cause a superficial burn to progress into a more severe and deeper wound. It is crucial to treat these wounds effectively to avoid complications and support healing [9,10].

Treatment strategies can be either conservative or surgical. Conservative treatments focus on wound care, infection prevention, and maintaining a moist environment to support healing. However, surgical interventions are often necessary to manage severe burns. One common surgical treatment is the excision of eschar, the dead tissue that forms over a burn wound. It's essential to remove the eschar to prevent infection and aid in healing [11].

After removing the eschar, the wound is usually covered with an autologous split-thickness skin graft. This involves harvesting healthy skin from another part of the patient's body and transplanting it to cover the burn wound. This procedure promotes healing by providing a protective layer and supporting tissue regeneration [12].

When extensive portions of the body surface are involved, autologous skin grafts are frequently meshed to increase their coverage area. This meshing technique allows a smaller piece of skin to cover a larger area, making it especially useful in extensive burn injuries. By expanding the graft, the surgeon can ensure adequate coverage and reduce the need for multiple grafting procedures. This approach enhances the patient's recovery by improving wound healing and reducing the risk of complications associated with large burn areas [13].

The disadvantages of such practices are morbidity, like pain at the donor site and corrugated scar at the recipient site. In situations where there are extensive full-thickness skin injuries and donor sites are insufficient, alternative treatments such as allografts or heterografts are utilized. These allografts serve as temporary solutions to cover wounds immediately after injury during the acute stages. Allografts can be live donor skin grafting or cadaveric skin grafts. Disadvantages of using allografts with live or cadaveric human skin are donor shortage, limited availability, moral objections, risk of viral transmission, etc. All these disadvantages of allografts make space for fully synthetic, biocompatible skin bio-construct which can help in the regeneration of scar-free skin. Tissue-engineered skin grafts strive to facilitate thorough, natural, and accelerated wound healing [14].

A scaffold or template is a 3-dimensional supporting framework for tissue regeneration, preventing wound bed contraction throughout the stages of healing.3 The framework, or scaffold, should further serve as a platform for cellular localization, adhesion, and differentiation, as well as guide the development of new functional tissues.4 Scaffold materials may be of natural, synthetic, or composite origin. The mixing of materials of different classes to obtain composite scaffolds helps to overcome the individual limitations of a single material scaffold.5 The ideal skin regeneration scaffold should actively direct tissue formation and prevent scarring. Thus, much focus has been channeled into creating suitable biomimetic structures that can act as delivery vehicles for steam cells or Growth factors.

The synergistic tissue regenerating effects of a smart scaffold cocktail comprise scaffold surface patterns, growth factors, and stem cells which have the realistic potential of overcoming current barriers and enabling fast and complete skin regeneration. During natural wound healing, interactions between components of the extracellular matrix and surrounding cell-signaling molecules are responsible for the expression of growth factors and cytokines.

These interactions elicit cellular responses that ultimately lead to new tissue formation. Overwhelming activation of the inflammatory system and prolific recruitment of contractile cells typically leads to scar formation, often resulting in disfigurement and functional disability. Nowadays, some wounds are closed aseptically using sutures that obviate the need for a vigorous contractile response, creating more time for complete tissue regeneration. Here, external modulation of cell-signaling events via a finely tuned delivery of Growth factors or stem cells is thought to alter the wound environment, enabling orderly regeneration **[15]**.

In our study, we have materials of different origins to make a composite scaffold which can help to overcome the limitations of each. All four components are already well-documented and proven.

CONCLUSION

The three-layer regeneration scaffold is straightforward, economical, straightforward to prepare, and free of complications. Hospital stays were nearly identical to those of patients treated with allografts. The resulting scar quality is satisfactory. However, a larger-scale, multi-center study is needed to accurately assess the findings.

Competing interest

None

Declarations

Author's contributions

All authors made contributions to the article **Availability of data and materials*:*** Not applicable
financial support and sponsorship

None

Consent for publication

Not applicable

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