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Rethink Complex Wounds with Biodegradable Temporising Matrix (A Dermal Skin Substitute) - A Retrospective Analysis of Clinical Outcomes in 10 Patients

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Abstract: ***Background*: Complex wounds are common worldwide and necessitate an interdisciplinary, multimodal approach to achieve desirable functional and aesthetic benefits. Microbial colonization, aging population, and rising healthcare costs have all contributed to the economic, social, and clinical costs of complex wound care. This study evaluates effectiveness of biodegradable temporising matrix for treating complex wounds in patients with multiple comorbidities and polymicrobiological colonization. *Methods*: From March 2023 to December 2023, ten patients received treatment at SMS Hospital, Jaipur, using a biodegradable temporising matrix in patients who had complex wounds. We retrospectively studied the results of these patients. *Results*: The biodegradable temporizing matrix markedly enhanced wound healing, particularly in patients with various comorbidities and microbiological colonization. This makes it a dependable and promising alternative for reconstruction. *Conclusion*: It is important to use dermal skin substitutes like the biodegradable temporizing matrix to rebuild the dermal layer and to restore skin functions to normal. It exhibits adequate porosity, regulated biodegradation rates, minimal toxicity and immunogenicity, and retains the integrity of structure during degradation. Our findings suggest that the biodegradable temporising matrix is an effective treatment for complex wounds under challenging circumstances.***

Keywords: Biodegradable temporising matrix, complex wounds, dermal skin substitutes, polymicrobiological

1. Introduction

As one of the most prominent organs in the human body, the skin acts as a dynamic barrier to shield the body from chemical and mechanical harm as well as to stop the loss of fluid and heat. [1]

Due to their inclination to not heal by primary intention, complex wounds in plastic and reconstructive surgery pose substantial complications. [2]

"Complex" or "chronic" wounds differ from "simple" wounds like minor abrasions or surgical incisions in that they need special attention, which is frequently provided in an inpatient setting. [3]

The four criteria's used to define complex wounds are as follows:

1) A substantial loss of integument, whether acute or chronic (chronic wounds are defined as those that fail to heal autonomously within three months).
2) Adverse occurrences encompass infections that result in further tissue loss, including severe infections such as Fournier's gangrene.
3) Necrosis or diminished viability of the adjacent tissues.
4) Systemic disorders, such as diabetes, vasculitis, or immunosuppression, that hinder the body's intrinsic healing mechanisms. [4]

Complex wounds can affect a patient's quality of life significantly because they can cause chronic pain, reduce mobility, and require frequent, sometimes lengthy medical treatments. Examples of these wounds encompass burns, full-thickness wounds of the lower limbs, diabetic ulcers, pressure ulcers, chronic venous ulcers, and wounds resulting from significant necrotic processes such as necrotizing fasciitis or Fournier's gangrene. [3,6]

These wounds represent a significant clinical, social, and economic issue due to increased healthcare expenses, an aging population, and the growing challenges associated with polymicrobial colonization. [7]

At present, there are two categories of devices for early wound closure: passive and active. Passive products (such as Biobrane, a nylon weave mesh containing porcine collagen with an overlying seal) close the wound temporarily but require removal. Meshed allogeneic cadaveric skin is another passive device that is expensive, frequently of variable quality, and susceptible to immunological rejection.[8].

As an alternative, the active dermal matrix strategy, pioneered by Jack Burke and Ioannas Yannas, uses a scaffold which encourages autologous tissue growth to form a "neo-dermis". This approach seeks to improve results over conventional thin, meshed skin grafts, as demonstrated by the Integra Dermal Regeneration Template, a crosslinked bovine Type I

collagen scaffold with shark fin chondroitin-6-sulphate glycosaminoglycan and a silicone pseudoepidermis. However, it has drawbacks like exorbitant costs, protracted production periods, and the possibility of infection prior to neovascularization in patients with compromised immune systems. [9,10,11,12].

Some of the dermal skin substitutes that are used for complex wounds where standard skin grafting is not enough are made from biological materials and synthetic alternatives. We categorize these replacements based on their constituents, such as decellularized dermis from animal or human origins, completely biological materials as well as synthetic polymer alternatives.[13].

A summary of current dermal skin substitutes is presented in Table 1.

Table 1: A Summary of Current Dermal Skin Substitutes

Nomenclature of the dermal skin alternatives	Compound
MatriDerm	Bovine type I and type III collagen and elastin
Dermagraft	Tissue which has been bioengineered from neonates and incorporates dermal fibroblasts
AlloDerm	Allograft human dermis donated and treated to eliminate cells while maintaining the biological elements and morphology of the dermal matrix.
Integra	Dermal element of shark chondroitin-6-sulfate and bovine collagen type I applied to the wound, accompanied by an externally oriented silicone membrane.
De-novo Skin	Hydrogel derived from a dermo-epidermal component following cultivation of autologous skin tissue specimens
BTM	Biodegradable polyurethane foam featuring an interim non-biodegradable polyurethane seal

[14]

The Biodegradable Temporising Matrix (BTM), registered in Germany as a dermal skin substitute, provides an alternative for the artificial reconstruction of complex wounds.

This artificial matrix facilitates cell migration and neo-angiogenesis by acting as a scaffold for the neo-dermis as it develops. The 2 mm thick biodegradable polyurethane cell foam is encased in a non-biodegradable sealing membrane. Clinical trials on full-thickness wound defects have demonstrated the effectiveness of BTM in repairing them, demonstrating capillary refill two weeks after treatment. Phased procedures also incorporate split-skin grafting after the eventual removal of the sealing membrane. [16-19].

In vivo experiments on rat and porcine models have validated its biocompatibility and lack of systemic toxic effects or wound contracture, highlighting its usefulness in avoiding the moral and cultural dilemmas related to biological materials. [18,20].

Its application in the treatment of complicated wounds brought on by ailments like necrotizing fasciitis and burn patients has demonstrated encouraging functional and cosmetic results. [19, 22-26].

Aim

This study aims to assess the effectiveness of biodegradable temorising matrix in treating patients with complex wounds.

2. Methodology

Study Design and Participants

We envisioned the study as a retrospective, single-center review of patients treated with BTM for single complex wound. We initially did not explore additional reconstructive surgeries due to pre-existing co-morbidities and polymicrobial colonization. In order to analyze and consider their treatment data, all patients who volunteered to participate in the study provided informed consent.

Exclusion Criteria

Patients with the following conditions:

1) Patients having residual malignancy.
2) Females who were lactating, pregnant, or at danger of conception without contraceptive measure.
3) Patients with a history of allergies to polyurethane dressing materials.
4) Overtly infected wounds, which might hinder BTM from taking effect.
5) Refusal to participate in the study.
6) Patients participating in other clinical study that could potentially influence our study outcomes.

Data Collection

Between March 2023 and December 2023, 10 patients underwent BTM treatment at the Department of Plastic and Reconstructive Surgery at Sawan Man Singh Medical College and Hospital in Jaipur.

There were two females and eight males with a single complex wound. The analysis included patient demographics, BTM indications, surgery details, co-morbidities, and microbiological data. We used the anatomical regions separately to record the location of the wound. A summary of defect localization of complex wounds is presented in Table 2.

Table 2: A Summary of Defect Localization of Complex Wounds in the Study Population (N=10)

Anatomical Region	Number of Wounds	Percentage of Total Wounds
Scalp	1	10%
Lower Leg	2	20%
Foot	3	30%
Hand	3	30%
Hand and forearm	1	10%
Total	**10**	**100%**

Microbial Analysis

In order to assess the microbial colonization of the wound, we collected wound swabs before the surgical wound cleaning phase, which is an essential part of the BTM transplantation surgical procedure.

The evaluation incorporated ten wound swabs from each of the ten patients. We noted and tabulated the differences between sterile wound swabs, mixed flora, and monobacterial colonization. An overview of prevalence of various pathogens is presented in Table 3.

Table 3: Pathogen Spectrum of Complex Wounds with Corresponding Prevalence

Pathogen Type	Number of Wounds with Isolated Pathogen	Number of Wounds with Mixed Flora	Sterile Wounds	Total Wounds Affected
Staphylococcus aureus	-	3	-	3
Pseudomonas aeruginosa	1	2	-	3
Escherichia coli	-	2	-	2
MRSA	-	1	-	1
No Growth	-	-	1	1
Total	**1**	**8**	**1**	**10**

Operative Procedure

The wound healing process with BTM consisted of four stages: adequate debridement and wound preparation, application of BTM, dressing changes every three to five days, and finally, delamination of the BTM followed by application of the split skin graft (SSG).

We applied the BTM to the peripheries of the full-thickness incision and used quilting staples or sutures as needed. The integration phase generally progresses from white to bright red, then to darker red and pink, as the tissue initially becomes engorged with blood and interstitial fluid, ultimately transforming into vascularized tissue.

Other indicators of successful integration include the matrix conforming to the wound bed, the foam pattern becoming imperceptible, and blanching upon pressure application, followed by capillary refill.

After integration, we removed and discarded the sealing membrane within a clinically acceptable timeframe. We debrided the wound bed and occluded it with a thin split-thickness skin graft in one session.

We also computed the intervals between BTM treatment and the ultimate defect coverage of the autologous split-thickness skin graft. We deemed over 90% of the take rates to be restorative. The minor residual defects underwent secondary wound healing.

Study Endpoints

We documented the patient's age, gender, and medical history, as well as their baseline characteristics. We used a clinical assessment and calculation per lesion to determine the primary endpoint, which was the percentage of applied BTM that underwent Split Skin Grafting at 7–10 days post-grafting.

Temporising matrices can be directly compared due to the objective nature of this final point, which is consistently documented in the available literature.

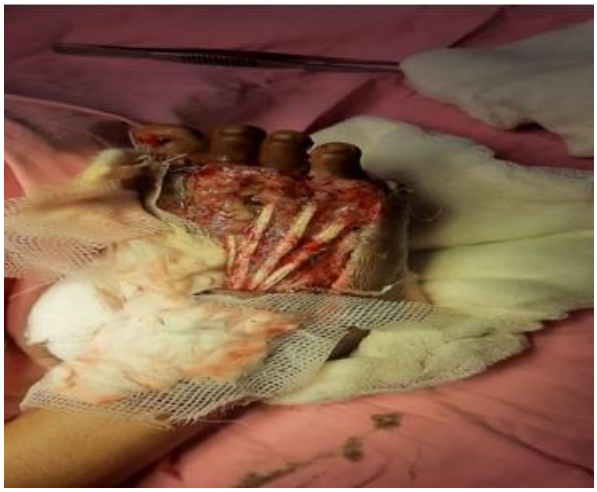
During the skin grafting procedure, we performed a clinical assessment of the area of BTM administered to each lesion and the proportion of BTM absorbed. We classed any combination of erythema, pain, purulence, or swelling as an infection, substantiated by microbiological evidence via swab, tissue microscopy, or culture.

We assessed the percentage of split-thickness skin grafts taken at 7–10 days post-grafting in relation to the total quantity of skin graft applied to each lesion.

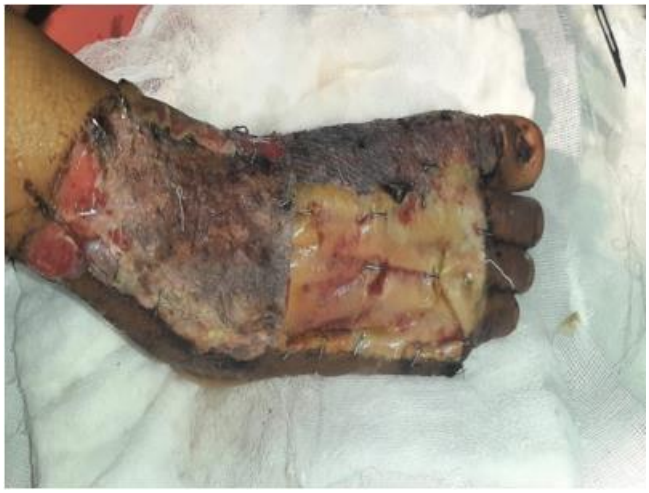
Clinical features have been shown below in figure 1

Figure 1

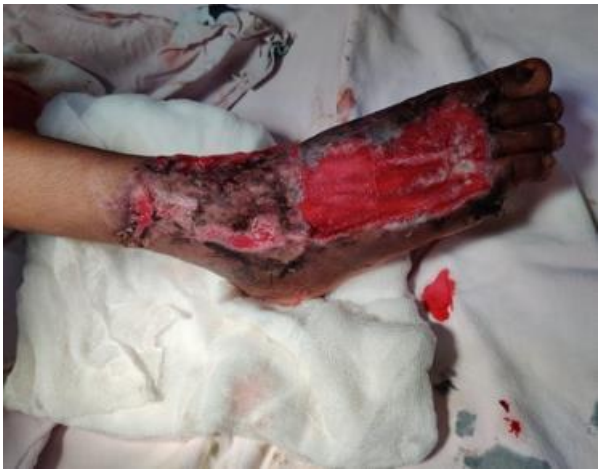
Case 1



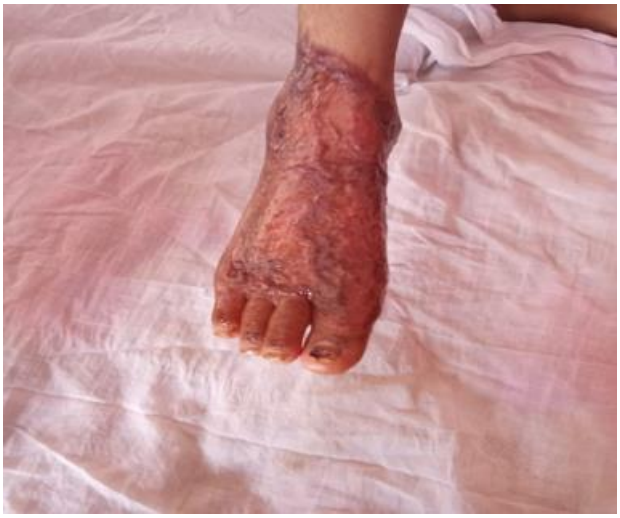
A) Pre-operative



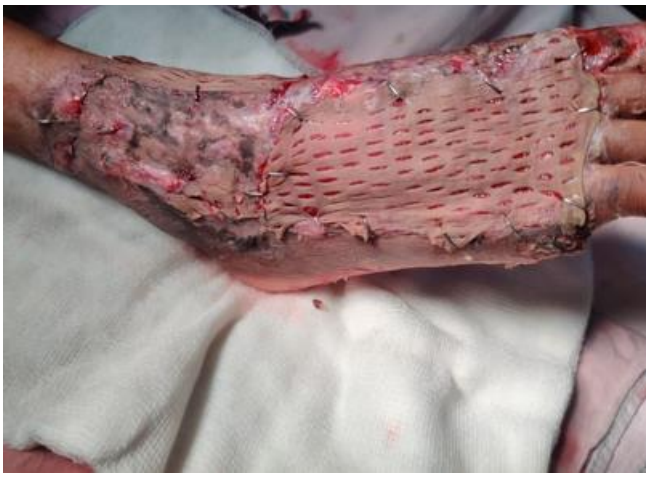
B) Post-operative (After 5 days of BTM application)



C) Healthy Granulation tissue observed after BTM Removal



E) Follow up after 1 month



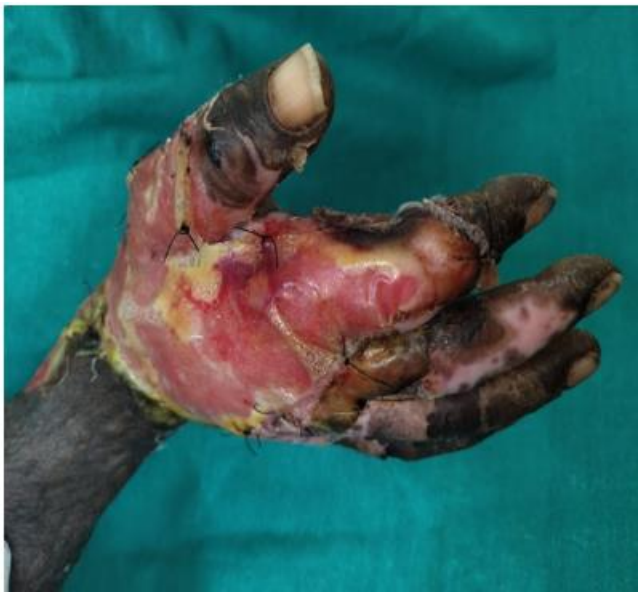
D) SSG Application

Case 2

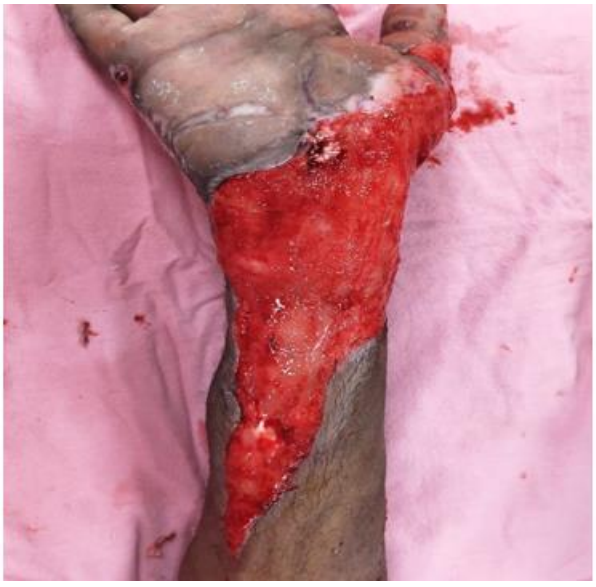
A) Pre-operative

B) 5 days post BTM application

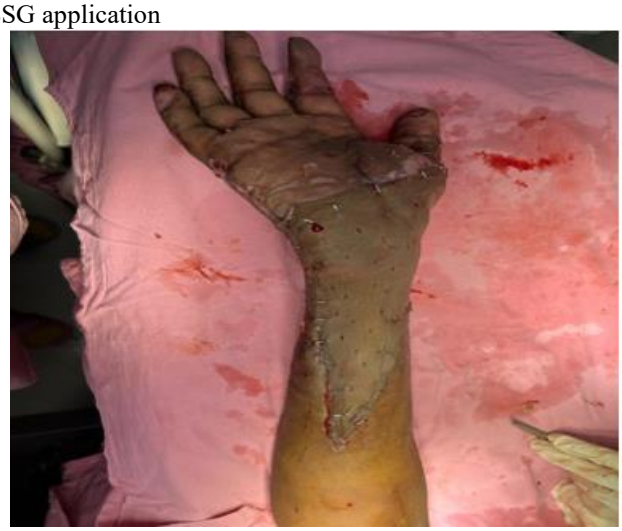

C) 10 days post BTM application

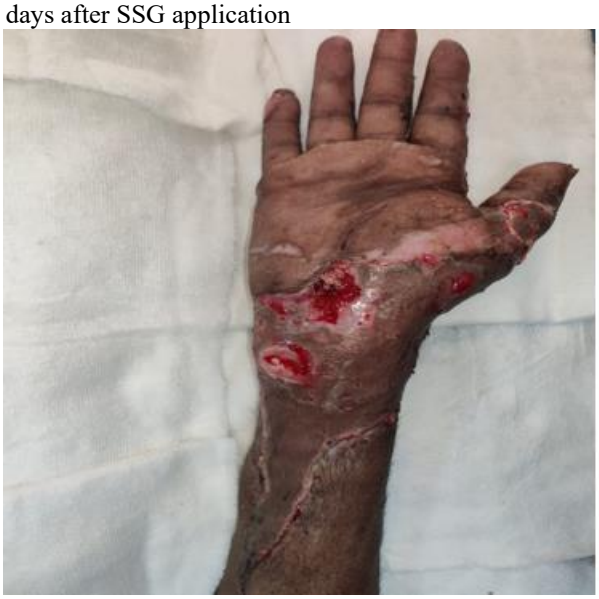
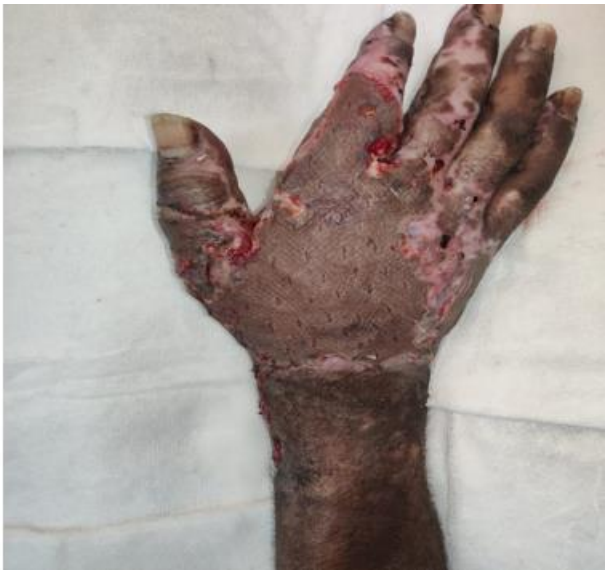
D) BTM removal




E) SSG application




F) 10 days after SSG application

Statistical Analysis

The study enrolled ten eligible individuals between March 2023 and December 2023, with each patient undergoing a BTM application for a single complex wound.

We used anatomical regions to identify each wounded site that received BTM treatment.

The oldest patient was 64 years old, while the youngest was 11 years of age. Eight of them were male, and two were female. Each patient underwent a staged approach for wound debridement.

Due to a polymicrobial infection associated with multiple co-morbidities along with poor compliance to regular dressings one of the patients was unable to recover and underwent multiple failed procedures at the end.

Following BTM administration, three individuals experienced an increase in pus discharge and a low-grade fever.

We readmitted the patients and started them on intravenous antibiotics based on the wound pus culture and sensitivity. We managed the patients by regularly changing the aseptic dressings and making small fenestrations in the dermal skin template and around the wound borders to facilitate discharge. After a delayed delamination, the patient's condition gradually improved. We assessed all ten individuals for safety issues, but found no prevalent reports of allergic reactions to polyurethane.

3. Discussion

The literature describes biodegradable polyurethane as a low-antigenicity polymer that provides regulated mechanical qualities, biodegradation rates, biocompatibility, and structural plasticity.

It belongs to a larger class of dermal substitutes called porous matrices made of synthetic and natural materials that are intended to mimic the vital roles of the extracellular matrix. [2].

The Biodegradable Temporizing Matrix (BTM), in contrast to the majority of commercially available dermal substitutes that contain xenogeneic components, is made entirely of synthetic polymers.

This composition circumvents the hazards and difficulties associated with allogeneic materials, including immunogenic reactions and disease transmission. Clinical benefits of BTM include affordability, extended shelf life, instant accessibility, robustness, adaptability, and a dependable barrier to infection, all essential for efficient wound care.[26].

A 150-um-thick, non-biodegradable polyurethane sealing membrane is attached to an open-cell, biodegradable polyurethane foam that is 2 mm thick in the BTM. This structure not only limits evaporative moisture loss and physiologically seals the wound, but it also delays wound contraction by preventing tissue coalescence on the matrix surface until clinical removal. [28, 29, 30, 31].

As seen in the scanning electron micrograph, the foam's high porosity (90%, with cell sizes ranging from 100 to 500 µm) promotes cutaneous tissue integration and speeds up biodegradation within 12–18 months in vivo. (Fig. 2).

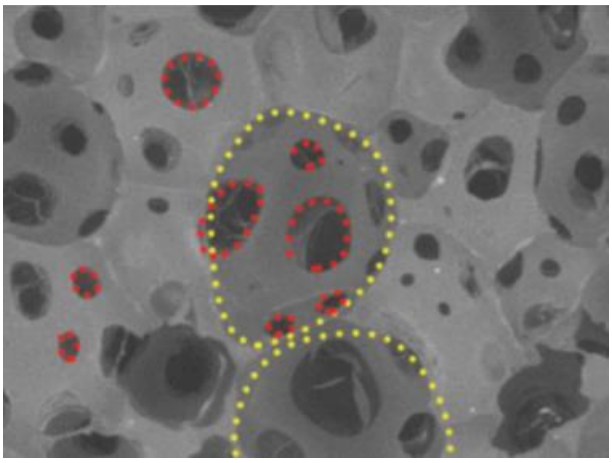


Figure 2: Scanning Electron Micrograph of BTM (Yellow Dots Indicate Chambers _1 Mm In Height; Red Dots Indicate Pores Averaging 188 µm and Connecting Chambers)

[27]

When the soft segments in its chemical chains get hydrolyzed, biodegradable polyurethane breaks down and has less harmful effects in both vitro and in vivo settings. [33].

While waiting for the recovery of donor sites for impending split skin graft harvests, this degrading process is essential for temporarizing full-thickness wounds, including those from burns.

Because BTM is synthetic rather than biological, it lacks nutrients that would otherwise help bacteria grow, making it more resistant to infection and able to withstand bacterial contamination. [29,30].

Furthermore, the foam's porosity promotes collagen deposition, vascular and fibroblast infiltration, and the formation of a robust, dense, and pliable neodermis that mimics normal skin. [29,32].

Split skin grafts are applied to the newly vascularized dermis after the sealing membrane has been fully integrated for definitive wound closure.

The structural design of BTM minimizes wound contraction since it serves as a natural physiological sealing mechanism for extensive, full-thickness wounds, potentially mitigating deformities and functional limitations.[32]

Despite the advantages, the process of integrating BTM into the wound bed usually takes two to three weeks; in situations where exposed or poorly vascularized structures are involved, this time may increase to five weeks. [4,7,18].

Capillary buds need a certain amount of time to permeate the matrix and create sufficient vascularization. This is due to matrix thickness, porosity, and patient-specific characteristics such as age and comorbidities. [6,16].

The study we conducted reveals the possible postponement of wound healing linked to BTM's two-stage application procedure. Although this may provide a disadvantage in certain situations, it can prove beneficial in cases of severe burns where donor sites are few.

In these circumstances, the capacity to alter the timing according to the individual requirements of each patient is facilitated, and effective delamination and grafting have been documented up to 47 days post-administration.[3].

4. Limitations

Our research indicates that the two-stage application process of BTM could impede the healing of wounds. This may be a drawback, but it can be beneficial in severe burns with few donor sites. Larger number of cases with long term follow-up are required to confirm its versatility, cost-effectiveness, wound contraction & scar quality

5. Conclusion

The Biodegradable Temporising Matrix (BTM), which merges biological functioning with synthetic durability, offers a suitable approach to address complex wounds.

Its unique design, which includes a non-biodegradable sealing membrane and biodegradable polyurethane foam, keeps infections out while also helping blood flow and tissue integration.

Even with the potential need for an extended integration phase, BTM's clinical flexibility and lack of biological contamination hazards highlight its importance in advanced wound care.

Long-term studies and clinical trials are required to fully confirm its effectiveness and maximize its use in a variety of wound care scenarios.

Financial Support
Nil

Conflicts of Interest
Nil

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