Investigation of Biocompatible Wound Dressing and Skin Graft Treatment Methods in the Healing of Skin Wounds of 3rd Degree Burn Trauma in Motahari Hospital: A Clinical Trial

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Abstract

Background: One of the primary concerns among burn patients with third-degree skin injuries is the healing process and the severity of resulting skin lesions—an issue that has attracted considerable research attention. Accordingly, the present study aimed to evaluate the therapeutic effects of biocompatible wound dressings and skin grafting on the healing of third-degree traumatic burn wounds in patients admitted to Motahari Hospital.

Methods: This semi-experimental randomized clinical trial was conducted in 2024. The study population included 18 patients with third-degree traumatic burns covering less than 5 cm², referred to the Motahari Burn Center in Tehran. Data were collected using a researcher-designed form. Statistical analyses were performed using SPSS software, employing the Mann–Whitney and Spearman tests.

Results: The mean age of participants was 36.25 years, and most were male (77.77%). The leading cause of burns was gas exposure (44.43%), and 66.68% of patients had burns covering 25% to 45% of total body surface area. Patients treated with biocompatible wound dressings experienced significantly less scar formation, improved follicle and dermal appendage restoration, and more aesthetically favorable skin regeneration.

Conclusions: Addressing patients' concerns about wound healing is essential, and effective therapeutic approaches should be employed. Based on the study's findings, the use of biocompatible wound dressings is recommended in skin and burn recovery services.

Keywords: Biocompatible Wound Dressing, Skin Graft, Burn Injury, Skin Repair, Trauma

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Introduction

Severe skin injuries caused by trauma, burns, or chronic conditions such as diabetes represent a major challenge for many patients and have become the focus of extensive research efforts in recent years [1–3]. Wound care using appropriate dressings is essential to prevent infection and promote effective healing. Generally, the wound healing process involves four distinct yet interconnected phases: hemostasis, inflammation, proliferation, and remodeling [3]. These phases encompass various biological events, including local inflammation, cell migration and mitosis, angiogenesis and granulation tissue formation, connective tissue repair, extracellular matrix (ECM) remodeling, and ultimately, tissue regeneration [4–6].

Each stage has distinct mechanisms and timelines, which vary based on the depth and severity of the wound. Most advanced wound dressings aim

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to support these stages by maintaining a moist environment, controlling excessive exudate, and protecting the wound from infection—all critical for uninterrupted healing [7,8]. The rising incidence of chronic wounds—such as diabetic ulcers, traumatic injuries, and burn wounds—has led to increased demand for advanced wound care solutions. These wounds are prone to intense inflammatory responses, and conventional dressings may lead to secondary injury [3,5,9].

Over the past two decades, numerous advanced wound dressings have been developed based on the principles of moist wound healing, particularly for complex injuries such as severe burns [3,10]. Natural polymers like collagen, alginate, and cellulose have been widely studied due to their biocompatibility, moisture retention properties, and favorable vapor transmission rates [11–14]. Collagen, the primary component of ECM in skin tissue, accounts for about two-thirds of the skin's dry weight [15,16]. It facilitates fibroblast activation and promotes endothelial cell migration to the wound site, playing a vital role in tissue repair.

Cell-based scaffolds derived from decellularized xenogenic tissues have emerged as a promising treatment for skin wounds. However, challenges remain, particularly regarding improper healing processes that may result in excessive scar formation due to uncontrolled collagen deposition [17]. For clinical applications, cell-laden scaffolds that promote balanced collagen remodeling and effective skin regeneration are preferred. Additionally, these scaffolds must facilitate cell migration and infiltration of keratinocytes, fibroblasts, endothelial cells, and immune cells to support the complex healing process [18,19].

One promising approach involves the use of synthetic or biomimetic scaffolds. An extracellular matrix (ECM)-based scaffold containing sufficient bioactive molecules can support cellular growth and create an ideal environment for wound regeneration [20]. In a pilot study using a 1 cm^2 defect model, significant tissue regeneration was observed, including restoration of the epidermis and dermal appendages such as glands and hair follicles. Building on this success, the present study aimed to further develop nanostructured wound dressings for potential application in the treatment of extensive skin injuries in humans.

Following successful in vitro and in vivo animal model trials, the most effective synthetic scaffold formulations—those demonstrating favorable regeneration without the use of stem cells—were selected for clinical application. Final implantation procedures were performed by a specialized surgical team using autologous, solvent-processed human-derived scaffolds. Independent experts, not affiliated with the clinical team, were consulted to evaluate healing outcomes and ensure objectivity in data collection.

The biomaterial used in this study is similar in nature to Integra™—an FDA-approved synthetic skin substitute derived from fish skin using a mechanical (non-chemical) process that preserves its biochemical properties.

This product was developed to meet regional needs for effective skin substitutes. Its laboratory phase began in 2009 under the supervision of academic and clinical experts at Shahid Beheshti University of Medical Sciences. After demonstrating strong efficacy and reproducibility, the project was proposed for industrial application in 2013. Key features of this product include antibacterial properties, the ability to induce cell proliferation and migration, mechanical strength compatible with human skin anatomy, suture retention, non-scarring healing, absence of carcinogenic or mutagenic activity, oxygen permeability, scalable manufacturing technology, and potential for future controlled-release modifications.

Given the urgent need for effective skin trauma treatment options, this study aimed to compare biocompatible wound dressings and skin grafting methods for third-degree burn wound repair at Motahari Hospital.

Methods

This study was a semi-experimental randomized clinical trial conducted in 2024. The study population comprised patients with third-degree traumatic burns smaller than 5 cm^2 who were referred to the Motahari Burn Center in Tehran. Based on previous studies and using G*Power software for sensitivity and specificity analysis, the sample size was calculated with a 95% confidence level and 80% statistical power, resulting in 9 patients in the intervention group and 9 in the control group (total: 18). Participants were selected using convenience sampling.

Data collection was performed using a researcher-designed form consisting of two sections: demographic information and clinical/wound-specific data. The face and content validity of the instrument were confirmed by 10 clinical experts, including burn surgeons from the Motahari Burn Center.

Eligible patients who consented (or whose guardians consented) after being informed about the purpose and procedures of the study were enrolled. Patients were randomly assigned to either the intervention group (biocompatible wound dressing) or the control group (skin grafting) using simple random allocation.

Statistical analysis was conducted using SPSS software version 24. Descriptive statistics were

Table 1: Demographic Characteristics of study Participants

Variable	Category	Frequency	Percentage
Gender	Male	14	77.77
	Female	4	23.22
Cause Of Burn	Contact With Hot Substance	4	23.22
	Gas	8	44.43
	Gasoline	4	21.23
	Electric	2	11.11
Burn Surface Area	<25%	3	16.66
	25-45%	12	66.68
	>45%	3	16.66
Age	Mean	36.25	
	Standard Deviation	13.32	

Table 2: Comparison of Treatment Outcomes Between Groups

Variable	Group	N	Mean (%)	SD	Statistical Results
Scar Retention	Biocompatible dressing	18	216	2.7	Z=3/32
	Skin graft	18	433	4.74	df = 18 p-value = 0.05
Follicle And Appendage Regeneration	Biocompatible dressing	18	172	1.7	Z=-42/2
	Skin graft	18	751	3.64	df = 18 p-value = 0.05
Skin Appearance After Healing	Biocompatible dressing	18	677	1.41	Z=2/32 df = 18
	Skin graft	18	316	3.35	p-value = 0.04
Infection Rate	Biocompatible dressing	18	123	4.8	Z=5/87
	Skin graft	18	125	4.9	df = 18 p-value = 0.07
Graft Rejection	Biocompatible dressing	18	143	3.3	Z=-53/6
	Skin graft	18	143	3.3	df = 18 p-value = 0.06
Tissue Strength	Biocompatible dressing	18	187	7.6	Z=5/71
	Skin graft	18	185	7.5	df = 18 p-value = 0.57

reported using frequency and percentage for qualitative variables, and mean ± standard deviation for quantitative variables. The Kolmogorov–Smirnov test was used to assess data normality. Due to the non-normal distribution of outcome variables, the Mann–Whitney U test was used for group comparisons, and Spearman's correlation was used to assess associations.

Results

The mean age of participants was 36.25 ± 13.32 years, with most being male (77.77%). The most common cause of burn injury was gas exposure (44.43%), and the majority of patients (66.68%) had burns involving 25% to 45% of the total body surface area. Table 1 presents the demographic characteristics of the participants.

To evaluate the suitability and accuracy of each treatment method and to select appropriate statistical tests, the normality of the data was initially assessed using the Kolmogorov–Smirnov test.

The results indicated that data related to scar retention, regeneration of hair follicles and dermal appendages, and skin aesthetics after healing were not normally distributed between the two treatment groups (P-value > 0.05). Therefore, the non-parametric Mann–Whitney U test was used to compare the means of these variables.

The Mann–Whitney test results showed statistically significant differences between the groups in scar retention, follicular and appendage regeneration, and skin appearance after healing at the 95% confidence level. Specifically, scar reduction, follicular regeneration, and post-treatment skin aesthetics were significantly improved in the biocompatible wound dressing group compared to the skin graft group (P-value < 0.05) (see Table 2).

Further analysis revealed no statistically significant differences between the groups in terms of infection rate, graft rejection, or tissue strength at the 95% confidence level. These variables were not meaningfully affected by the type of treatment.

Due to the non-parametric nature of the data,

Table 3: Relationship between the therapeutic procedure performed and the rate of hair follicle and appendage repair and skin beauty after repair

Variable	Spearman's P	P-value	N
Follicle And Appendage Repair	-0.261	0.02	18
Skin Beauty After Repair	-0.187	0.04	18

Spearman's rank correlation was used to assess relationships between the treatment type and the variables of follicular regeneration duration and post-healing skin appearance (see Table 3).

The Spearman correlation test results demonstrated a statistically significant relationship between treatment type and follicular and appendage regeneration, as well as skin aesthetics after healing (P-value < 0.05). These findings indicate that biocompatible wound dressings had a more favorable impact on these outcomes compared to skin grafting.

Discussion

The present study aimed to evaluate the therapeutic efficacy of biocompatible wound dressings versus skin grafting in the repair of third-degree traumatic burn wounds at Motahari Hospital. One objective was to assess the demographic characteristics of the patient sample, using descriptive statistics reported in the Results section.

Regarding age, the patient sample was relatively homogeneous, with a mean age of 36.25 years and a standard deviation of 13.32. In comparison, a 2017 study by Haisheng et al. in China reported a mean age of 27 years, with the 0–6-year age group comprising the largest proportion (34.7%) [21]. Additionally, a 2016 meta-analysis by Saberi et al. on burn and skin graft epidemiology in Iran found that most participants were aged between 16 and 29 years [22]. These age differences may be attributed to variations in inclusion criteria, as the cited studies enrolled patients without age restrictions.

Burn surface analysis revealed that the majority of patients sustained burns involving 25% to 45% of their total body surface area—an outcome consistent with the study's broad inclusion criteria regarding burn extent.

With respect to burn etiology, gas exposure was the leading cause (44.43%), aligning with findings by Amiralavi et al., who also identified gas as the predominant source of burn injury [23]. In contrast, Saberi et al.'s meta-analysis found flame burns to be the most common cause [22]. The diversity in causes observed here supports the plausibility of findings based on random sampling and underscores the importance of public education on burn prevention, particularly in relation to gas safety.

Analytical results indicated no statistically significant differences between the biocompatible wound dressing and skin graft groups in terms of tissue strength, graft rejection, or infection rates. All three outcomes were equivalent and uniformly favorable across both groups during the study period.

Regarding core therapeutic outcomes, the biocompatible wound dressing group demonstrated significantly better scar reduction, follicular and appendage regeneration, and post-healing skin aesthetics, compared to the skin graft group, with findings statistically significant at the 95% confidence level (P < 0.05). This suggests that biocompatible wound dressings offer substantial advantages over conventional skin grafts in clinical outcomes related to aesthetics and tissue restoration.

The superior performance of biocompatible dressings may be attributed to several key features: their advanced scaffold technology; epidermal and dermal reconstruction capabilities; cell-free application; antibacterial properties; stimulation of edge-based cell proliferation; controlled migration at wound margins; anatomical compatibility; suture retention; scar-free healing; absence of carcinogenic or mutagenic effects; oxygen permeability; affordability; and potential for future enhancement through slow-release systems. Collectively, these benefits contribute to the therapeutic superiority and broader clinical acceptability of this intervention over traditional skin grafting.

Conclusion

Based on the study results, biocompatible wound dressings significantly reduce scar formation, improve follicular and appendage regeneration, and enhance skin aesthetics in third-degree burn patients. Additionally, this method appears to be more convenient and satisfactory for both patients and healthcare providers. It is therefore recommended that biocompatible dressings be adopted as a preferred option in burn and skin repair centers..

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Conflict of Interest

The authors declare that they have no conflict of interest regarding the publication of this article.

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