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Effect of Elastomull® elastic bandaging on second-degree burn wound healing in Wistar rats: A preliminary study

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ABSTRACT

Background: Second-degree burns are the most common burn injuries, requiring effective wound management to prevent complications. While silver sulfadiazine is the gold standard treatment, the role of elastic bandaging in enhancing healing remains unclear.

Objective: To investigate the effectiveness of Elastomull® elastic bandaging combined with silver sulfadiazine in treating second-degree burns in Wistar rats.

Methods: Six male Wistar rats were divided into two groups: K(+) group treated with silver sulfadiazine and Elastomull® bandaging, and K(-) group treated with silver sulfadiazine alone. Second-degree burns were induced using a 100°C iron applied for 5 seconds. Wound areas were measured every three days for 18 days and analyzed using Independent-Samples T-Test.

Results: The K(+) group consistently showed smaller wound areas from day 3 onwards, with greater total healing (1.87 ± 0.25 cm^2) compared to K(-) group (1.03 ± 0.53 cm^2). However, differences were not statistically significant ($p > 0.05$).

Conclusion: Elastomull® bandaging showed clinical trends toward improved burn healing but lacked statistical significance, likely due to small sample size. Larger studies are needed to confirm these findings.

Keywords: Burn wound healing, Elastomull, elastic bandaging, silver sulfadiazine, Wistar rat

Introduction

Burns represent a significant global health burden, causing substantial morbidity, mortality, and economic impact. In 2019, approximately 8.4 million new burn cases occurred worldwide, resulting in over 111,000 deaths [6]. These injuries arise from various sources including heat, electricity, friction, chemicals, and radiation, with severity classified by the depth of skin layer involvement [1–3]. Second-degree burns, which damage both the epidermis and dermis, are the most frequently encountered burn type, particularly in household settings [5]. The prevalence of burns in Indonesia stands at 0.7% of the population, with higher incidence in males (55.7%) compared to females (44.3%) [7,8].

The economic burden of burn injuries is substantial. Healthcare costs per burn patient average US$88,218, with significant variation depending on injury severity (range US$704–717,306) [9]. Beyond direct medical expenses, indirect costs including lost productivity, extended care requirements, and psychological support further amplify the economic impact on patients and healthcare systems [9]. This considerable burden necessitates effective and cost-efficient burn management strategies.

Burn wound healing is a complex, multifaceted process influenced by numerous factors, making burns among the most challenging wounds to manage effectively. Inadequate treatment can lead to serious complications including infection, shock, plasma loss, and contracture formation [2,4]. Infection by pathogenic organisms represents a particularly critical concern, as it can impede healing, spread to surrounding tissues, and potentially progress to life-threatening sepsis [2]. Consequently, patients with burn injuries require comprehensive management strategies incorporating both pharmacological and surgical interventions to minimize complications and optimize healing outcomes [2,4].

Current burn wound management centers on preventing infection while promoting optimal healing conditions. Silver sulfadiazine has been established as the gold standard topical antibiotic for burn treatment due to its broad-spectrum antimicrobial activity [11–13]. The silver ions in this medication exert cytotoxic effects against bacteria, viruses, and fungi, thereby reducing infection risk [14]. However, pharmacological treatment alone may be insufficient for optimal wound healing.

Wound dressings play a crucial complementary role in burn management by maintaining appropriate moisture levels, absorbing excess exudate, and providing mechanical protection [2,10]. Various dressing materials are available, including gauze, hydrocolloids, alginates, hydrogels, and elastic dressings. Among these, elastic dressings such as Elastomull® offer potential advantages through their ability to maintain moist wound environments while conforming to body contours and allowing movement [10]. The ideal burn dressing should be non-adherent to minimize trauma during changes, absorbent to manage exudate, and possess antimicrobial properties [10].

Traditional dry gauze dressings have significant limitations, promoting scab formation and causing considerable pain upon removal [15]. In contrast, the combination of silver sulfadiazine with elastic dressings like Elastomull® addresses multiple wound care requirements: antimicrobial protection from silver sulfadiazine, non-adherent properties to prevent tissue damage during dressing changes, and absorbency to manage exudate [15]. This combination theoretically supports all three phases of wound healing—inflammation, proliferation, and remodeling—potentially reducing overall healing time [2].

Despite the widespread clinical use of elastic bandaging in burn management, limited scientific evidence exists regarding its specific contribution to healing outcomes when combined with standard topical antibiotics. Understanding whether elastic bandaging provides measurable benefits beyond silver sulfadiazine treatment alone has important implications for evidence-based burn care protocols and resource allocation in clinical settings.

This study aims to investigate the effect of Elastomull® elastic bandaging on healing time of second-degree burns in Wistar rats as a preliminary investigation. By establishing baseline methodology and initial data, this research will inform the design of larger-scale studies examining both elastic bandaging and other potential therapeutic interventions for burn wound management.

Methods

Test animals and ethical approval

The animals used in this research were Wistar rats (*Rattus norvegicus*) obtained from a research animal farm supervised by the Faculty of Veterinary Medicine at Syiah Kuala University, Banda Aceh. The experimental animals were healthy male Wistar rats aged between 12-16 weeks, with body weights of 200-300 grams. This study was approved by Syiah Kuala University's Faculty of Veterinary Medicine Veterinary Ethics Committee (Number 215/KEPH/V/2023). As this is a preliminary study designed to establish baseline methodology before conducting larger-scale research into burn wound treatments, six experimental animals were used, divided into two test groups of three rats each: the K(+) group (rats bandaged with Elastomull®) and the K(-) group (rats not bandaged with Elastomull®). While this sample size limits statistical power, as acknowledged in our limitations, it serves the purpose of this preliminary investigation.

Animal preparation and acclimatization

The rats were acclimatized in individual cages (34 cm × 29 cm × 11 cm) at room temperature with water and a standard diet available ad libitum for 7 days. The rats were separated according to their test groups. Both groups received second-degree burns: the K(+) group was treated with silver sulfadiazine and wrapped with Elastomull® elastic bandage, while the K(-) group received silver sulfadiazine without bandaging. This design was chosen because silver sulfadiazine alone is considered the gold standard for burn wound treatment, and this study examines whether additional dressing with Elastomull® improves healing outcomes. The rats were fasted for 12 hours before the burn induction procedure, with water provided normally, to ensure all rats were in the same metabolic state.

Induction of second-degree burns

After the 12-hour fasting period, rats were anesthetized with a ketamine/xylazine cocktail (0.1 mL/100 grams body weight) administered intramuscularly. Under anesthesia, the dorsal surface hair was shaved using an electric hair clipper, and the skin was cleaned with 70% ethanol swabs.

Burn induction was performed using a soldering iron with a square-shaped tip measuring 1 cm × 1 cm. The iron was heated to 100°C (verified with a thermometer) and applied to the rats' backs without pressure for 5 seconds to produce second-degree burns. These parameters were selected based on research by Cai et al., which identified five factors determining burn wound depth in rats: skin temperature, material of the burn-inducing instrument, temperature of the instrument, weight applied to the animal's body, and duration of induction [16]. Five minutes after burn induction, treatments were applied according to each group's protocol.

Wound treatment protocol

The K(-) group received topical silver sulfadiazine without bandaging, while the K(+) group received topical silver sulfadiazine and was wrapped with Elastomull® elastic bandage. The bandages were changed and medication was reapplied once daily until day 18. This daily changing protocol was implemented to ensure consistent wound cleanliness and medication application, though we acknowledge in our limitations that changing bandages every three days may be more optimal for granulation tissue formation.

Data collection and measurements

Burn wound area was measured every three days using a caliper to obtain the length and width of the wound in centimeters. The burn area was calculated by multiplying length by width to obtain values in square centimeters (cm^2). Body weight of the test animals was also recorded every three days. On day 18, the study concluded and rats were euthanized by cervical dislocation.

Data analysis

Data were analyzed using IBM SPSS Statistics software. The wound areas between groups were compared using the Independent-Samples T-Test to assess mean differences. Prior to conducting the T-Test, data normality was assessed using the Shapiro-Wilk test, and homogeneity was evaluated using Levene's test, as these are requirements for parametric testing. If data failed to meet normality and homogeneity assumptions, the non-parametric Mann-Whitney test would have been conducted instead. Statistical significance was defined as $p \leq 0.05$.

To assess overall healing progression, the change in wound area (Δ) from day 0 to day 18 was calculated by subtracting the final wound area from the initial wound area, and this Δ-value was compared between groups using the Independent-Samples T-Test.

Results

Wound area progression

Burn injury testing was carried out on six Wistar rats divided into two groups of three animals each. Group K(+) received silver sulfadiazine with Elastomull® bandaging, while group K(-) received silver sulfadiazine without bandaging. Wound area was measured every three days from day 0 to day 18 (Figure 1).

The average wound area data from both groups (Table 1) are displayed graphically in Figure 2.

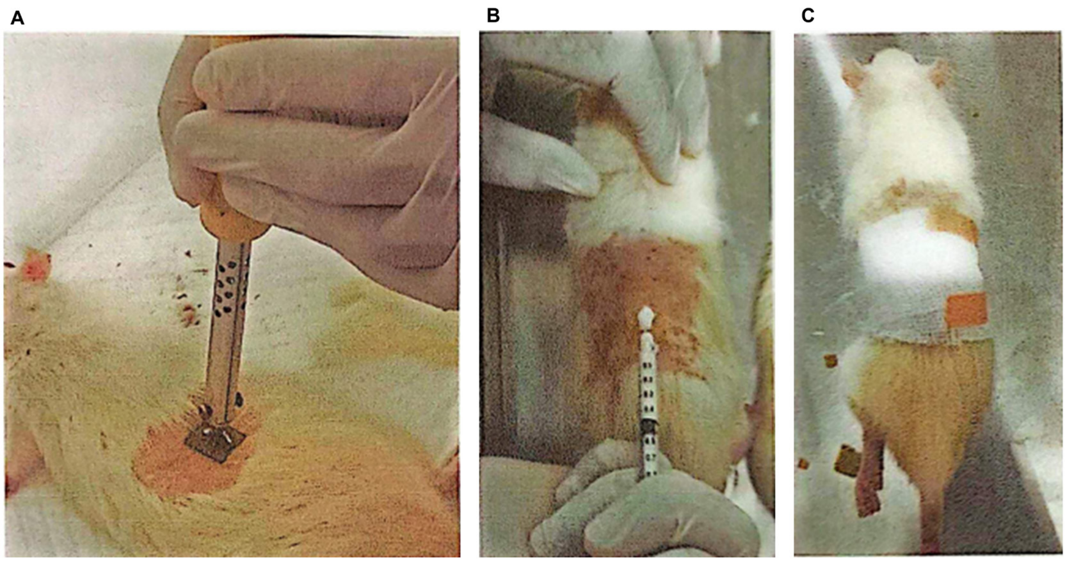

Figure 1. Burn wound treatment procedure. (A) Burn wound induction. (B) Silver sulfadiazine application. (C) Wound dressing

Table 1. Average wound area over time

Days	Average wound area ± Standard deviation (cm^2)		*p*
	K(+)	K(-)	
0	2.07 ± 0.27	1.76 ± 0.13	0.145
3	2.96 ± 0.49	3.52 ± 0.49	0.230
6	2.59 ± 0.12	2.99 ± 0.54	0.273
9	2.19 ± 0.28	2.42 ± 0.34	0.407
12	1.55 ± 0.26	1.64 ± 0.58	0.832
15	0.43 ± 0.37	1.29 ± 0.39	0.053
18	0.20 ± 0.17	0.73 ± 0.41	0.109

Notes: K(+), group bandaged with Elastomull®; K(-), group not bandaged with Elastomull®; *p*, Independent-Samples T-Test significance value

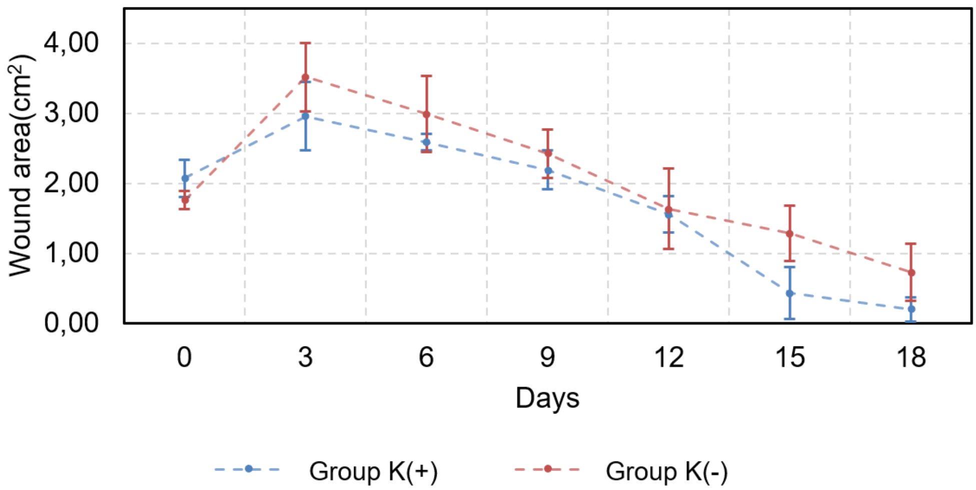

Figure 2. Progression of burn wound area over 18 days in bandaged and unbandaged treatment groups. Mean wound area (cm^2) measured at three-day intervals in Wistar rats with second-degree burns. K(+) group: silver sulfadiazine with Elastomull® bandaging; K(-) group: silver sulfadiazine alone. Both groups showed initial wound expansion on day 3 (inflammatory phase) followed by progressive healing from day 6 onwards (proliferative phase). The bandaged group consistently demonstrated smaller wound areas throughout the observation period. Error bars represent standard deviation (n=3 per group)

Prior to statistical comparison, data normality was verified using the Shapiro-Wilk test. The K(+) group showed a significance value of 0.093, and the K(-) group showed 0.917, both indicating normal distribution ($p \geq 0.05$). This confirmed the appropriateness of using the Independent-Samples T-Test.

The T-Test results showed no statistically significant differences between groups at any observation time point (all $p > 0.05$). On day 3, both groups demonstrated wound expansion compared to day 0, consistent with the inflammatory phase of wound healing. Subsequently, wound areas decreased in both groups from day 6 onwards, indicating progression to the proliferative phase.

Notably, beginning on day 3 and continuing through day 18, the bandaged group consistently maintained smaller wound areas than the unbandaged group. The most pronounced difference occurred on day 15, when the K(+) group showed a mean wound area of 0.43 ± 0.37 cm^2 while the K(-) group measured 1.29 ± 0.39 cm^2 ($p = 0.053$).

Total healed wound area

To assess overall healing effectiveness, the change in wound area from baseline to day 18 (Δ_{0-18}) was calculated and compared between groups (Table 2).

Table 2. Total healed wound area over 18 days

Δ	Average ± Standard Deviation (cm^2)		*p*
	K(+)	K(-)	
$\Delta_{0\text{-}18}$	1.87 ± 0.25	1.03 ± 0.53	0.067

Notes: K(+), group bandaged with Elastomull®; K(-), group not bandaged with Elastomull®; *p*, Independent-Samples T-Test significance value

The bandaged group demonstrated greater total wound healing (1.87 ± 0.25 cm^2) compared to the unbandaged group (1.03 ± 0.53 cm^2) over the 18-day observation period. However, this difference did not reach statistical significance ($p = 0.067$).

Discussion

This study investigated the effect of Elastomull® elastic bandaging on healing time of second-degree burns in Wistar rats. Our findings demonstrated that rats treated with silver sulfadiazine and Elastomull® bandaging (K(+) group) consistently maintained smaller wound areas compared to rats treated with silver sulfadiazine alone (K(-) group) from day 3 onwards throughout the 18-day observation period. The bandaged group showed greater total wound healing (1.87 ± 0.25 cm^2) compared to the unbandaged group (1.03 ± 0.53 cm^2), with the most pronounced difference observed on day 15, when the bandaged group's wound area had reduced to 0.43 ± 0.37 cm^2 while the unbandaged group remained at 1.29 ± 0.39 cm^2. However, despite these clinically observable differences, statistical analysis using the Independent-Samples T-Test revealed no significant differences between groups at any time point (all $p > 0.05$), including the overall healing comparison ($p = 0.067$).

The initial burn induction on day 0 resulted in different wound areas between groups, with the K(+) group showing a larger average burn area (2.07 ± 0.27 cm^2) compared to the K(-) group (1.76 ± 0.13 cm^2), though this difference was not statistically significant ($p = 0.145$). This variation can be attributed to several factors that influence burn depth and extent. According to Cai et al., burn wound characteristics in rats are determined by skin temperature, material and temperature of the burn-inducing instrument, applied weight, and induction duration [16]. Additionally, rats possess loose, elastic skin that is not tightly attached to underlying tissue [17], which can lead to variations in burn depth even when standardized burn induction protocols are applied.

Both groups demonstrated wound expansion on day 3, indicating entry into the inflammatory phase of wound healing. The inflammatory phase, which begins within 24 hours of injury [4], is characterized by vasodilation, fluid extravasation, and edema [18]. The average wound area in the K(+) group expanded to 2.96 ± 0.49 cm^2, while the K(-) group expanded to 3.52 ± 0.49 cm^2. This pattern aligns with findings by Chen et al., who observed wound area increases on day 2 in their burn study, with subsequent reduction beginning on day 4 [19]. During this inflammatory process, which continues until approximately the fourth day after injury, significant exudate production occurs [20]. Excessive exudate can impede burn wound healing [21], and the role of bandaging during this phase is to absorb exudate while maintaining optimal wound moisture. Our results showed that on day 3, the K(+) group had a smaller wound area than the K(-) group, suggesting that Elastomull® bandaging effectively absorbed exudate and supported healing during the inflammatory phase. However, the T-Test revealed no significant difference between groups (p = 0.230), indicating that while Elastomull® may provide clinical benefits, these effects were not statistically significant in this small sample.

From day 6 onwards, wound areas began decreasing in both groups, marking the transition to the proliferative phase. The inflammatory phase typically lasts until the fourth day before transitioning to the proliferative phase [22]. During proliferation, reepithelialization occurs in response to signals from macrophages, cytokines, and growth factors released during inflammation. Granulation tissue formation is triggered by fibroblast migration to the wound area [22]. Throughout days 6, 9, and 12, no significant differences were observed between groups (p = 0.273, p = 0.407, p = 0.832, respectively), suggesting that bandaging effects during early proliferation were not statistically distinguishable from treatment with silver sulfadiazine alone.

A notable finding emerged on day 15, when the K(+) group demonstrated dramatically reduced wound areas (0.43 ± 0.37 cm^2) approaching complete healing, while the K(-) group still maintained larger wounds (1.29 ± 0.39 cm^2). This substantial reduction can be attributed to Elastomull®'s non-adhering properties. According to Wiegand et al., non-adhering dressings prevent damage to newly formed tissue during dressing changes and positively influence wound healing by promoting fibroblast activity, thereby accelerating tissue proliferation [23]. Despite this clinically apparent difference, statistical analysis showed borderline but non-significant results (p = 0.053). By day 18, the pattern continued with the K(+) group maintaining smaller wound areas (0.20 ± 0.17 cm^2) compared to the K(-) group (0.73 ± 0.41 cm^2), though again without statistical significance (p = 0.109).

The lack of statistical significance in our results, despite observable clinical trends favoring bandaging, can be attributed to several methodological limitations. First, the small sample size (n = 3 per group) substantially limited statistical power, making it difficult to detect significant differences even when clinical trends were apparent. Second, high variability in the data, particularly evident in the larger standard deviations observed in the K(-) group, further reduced the ability to achieve statistical significance. Third, the study duration of 18 days captured only the inflammatory and proliferative phases without extending to complete wound healing or the remodeling phase, potentially missing differences that might emerge with longer observation periods.

An important methodological concern was the daily bandage changing protocol employed in this study. Ideally, bandages should be changed every three days to minimize irritation and avoid disrupting granulation tissue proliferation. Daily changes may have interfered with the natural healing process and contributed to the inconsistent significance across time points. This represents a significant protocol deviation from optimal wound care practices and may have diminished the potential benefits of bandaging.

Additionally, wound area measurement using length × width calculations may have introduced bias, as wounds did not always maintain perfectly square shapes. More sophisticated measurement methods, such as digital imaging analysis applications, could provide greater accuracy in future studies. The method of burn induction could also be improved by stretching the rat skin before applying heat, which would prevent skin contraction during induction and reduce variations in wound depth and shape.

Despite these limitations, our findings suggest that silver sulfadiazine remains the gold standard in burn wound management, with bandaging serving as a complementary intervention. The observable clinical improvements with Elastomull® bandaging—particularly the consistent reduction in wound area from day 3 onwards and the dramatic improvement on day 15—suggest potential benefits in both inflammatory and proliferative phases. However, the statistically insignificant results indicate diminishing returns from bandaging beyond standard silver sulfadiazine treatment in this experimental model.

The clinical implications of these findings should be interpreted cautiously. While the bandaged group demonstrated numerically superior healing, the lack of statistical significance means we cannot definitively conclude that Elastomull® bandaging provides additional benefit beyond silver sulfadiazine alone based on this preliminary data. Future research with larger sample sizes, refined burn induction techniques, optimized bandage changing protocols (every three days), and extended observation periods through complete wound healing would be necessary to definitively establish the role of elastic bandaging in second-degree burn management. Histological analysis would also provide valuable insights into the cellular-level effects of bandaging on different wound healing phases.

Conclusion

Second-degree burns in Wistar rats treated with silver sulfadiazine and Elastomull® elastic bandaging demonstrated consistently smaller wound areas from day 3 onwards compared to silver sulfadiazine treatment alone, with the bandaged group achieving greater total healing (1.87 ± 0.25 cm^2 vs. 1.03 ± 0.53 cm^2). The most pronounced difference occurred on day 15, suggesting that Elastomull® may facilitate wound healing during both inflammatory and proliferative phases. However, these differences were not statistically significant (all $p > 0.05$), likely due to the small sample size and methodological limitations. While clinical trends suggest potential benefits of elastic bandaging in burn wound management, larger studies with refined methodology are required to establish definitive conclusions.

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Declaration of interest

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Author contributions

NZ: Investigation, data collection, formal analysis, writing—original draft preparation. DS: Conceptualization, methodology, supervision, writing—review and editing, project administration. M: Methodology, supervision, validation, writing—review and editing. All authors have read and approved the final version of the manuscript.

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