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Original Research Article

Collagen sheet dressing versus conventional silver sulfadiazine dressing in the management of partial-thickness upper limb burns: a prospective comparative study

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ABSTRACT

Background: The objective was to compare collagen sheet dressing with conventional 1% silver sulfadiazine (SSD) dressing for partial-thickness upper-limb burns with respect to pain, dressing frequency, wound healing, infection, scar quality, and treatment cost.

Methods: This prospective comparative observational study included 60 adults with partial-thickness upper-limb burns treated with either collagen sheet dressing (n=30) or 1% SSD dressing (n=30). One patient in each group was lost to follow-up, leaving 58 patients for final analysis. Outcomes included pain, number of dressing changes, time to complete epithelialization, wound infection, scar quality, and overall treatment cost. Continuous variables were expressed as mean ± standard deviation and compared using the independent Student's t test. Categorical variables were expressed as frequency and percentage and compared using the Chi-square test or Fisher's exact test, as appropriate. A two-tailed p value <0.05 was considered statistically significant.

Results: The collagen group required fewer dressing changes than the SSD group (1.03±0.19 vs. 9.17±3.11; p<0.001), had lower pain scores at all assessed time points, and achieved complete epithelialization earlier (13.10±3.79 vs. 19.41±7.06 days; p<0.001). Wound infection occurred in 14% of the collagen group and 38% of the SSD group (p=0.009). Good scar quality was observed in 86% and 55%, respectively (p=0.035). Mean treatment cost was lower with collagen dressing (₹2716.55±794.19 vs. ₹3211.38±1027.45; p=0.045).

Conclusions: Collagen sheet dressing was associated with fewer dressing changes, less pain, faster epithelialization, lower infection rates, better early scar quality, and lower overall treatment cost than conventional SSD dressing in partial-thickness upper-limb burns.

Keywords: Burns, Collagen dressing, Silver sulfadiazine, Wound healing, Pain, Cost-effectiveness

INTRODUCTION

Burn injuries remain a major global public health problem and are associated with substantial morbidity, prolonged hospitalization, disability, psychological distress, and socioeconomic burden. Worldwide, burns account for approximately 180,000 deaths annually, with the majority occurring in low- and middle-income countries where access to specialized burn care remains limited.[1-3] Partial-thickness burns are among the most frequently encountered thermal injuries and involve destruction of the epidermis with variable extension into the dermis. Although these wounds retain the capacity for spontaneous re-epithelialization, delayed healing significantly increases the risk of wound infection, hypertrophic scarring, contracture formation, chronic pain, and long-term functional impairment, particularly when the upper extremities are involved.[3,4]

Contemporary burn management emphasizes early assessment of burn depth, prompt wound cleansing, infection control, maintenance of an optimal moist wound environment, adequate pain management, and preservation of function.[2,4,5] An ideal burn dressing should provide an effective barrier against microbial contamination while maintaining moisture balance, permitting gaseous exchange, minimizing evaporative fluid loss, reducing pain during dressing changes, and promoting rapid epithelial regeneration.[4,5,10] Despite advances in wound-care technology, identifying the most effective and cost-efficient dressing for partial-thickness burns remains an important challenge in modern burn care.[1,2]

For decades, 1% silver sulfadiazine (SSD) has been regarded as the standard topical antimicrobial agent for superficial and partial-thickness burns because of its broad-spectrum antibacterial activity.[2] However, increasing evidence has questioned its routine use because of several limitations. Daily or frequent dressing changes often result in repeated wound manipulation, increased pain, greater nursing workload, prolonged hospitalization, and higher overall treatment costs. Furthermore, experimental and clinical studies have demonstrated that silver sulfadiazine may exert cytotoxic effects on keratinocytes and fibroblasts, potentially delaying epithelialization and wound healing compared with newer biological dressings.[6,7]

Biological dressings have emerged as attractive alternatives to conventional topical antimicrobial agents. Among these, collagen-based dressings have gained considerable attention because collagen is the principal structural protein of the extracellular matrix and plays a pivotal role in every phase of wound healing. Collagen provides a natural scaffold for cellular migration, promotes fibroblast proliferation and angiogenesis, facilitates extracellular matrix remodeling, and supports rapid re-epithelialization.[8] In addition, collagen dressings reduce evaporative water loss, protect exposed nerve endings, decrease pain, and create a favorable microenvironment for tissue regeneration while reducing the frequency of dressing changes.[8,9]

Burn injuries involving the upper limb present unique reconstructive challenges because preservation of hand and upper-extremity function is essential for activities of daily living, occupational performance, and overall quality of life. Delayed wound healing and excessive scar formation in these regions may lead to joint stiffness, tendon adhesions, contractures, and permanent disability.[2,3] Therefore, treatment strategies capable of accelerating wound healing while minimizing pain, infection, and scar formation are of particular clinical importance.

Several randomized trials, systematic reviews, and meta-analyses have reported favorable outcomes with collagen dressings, including faster wound healing, fewer dressing changes, lower pain scores, reduced infection rates, improved patient satisfaction, and shorter hospital stay compared with conventional dressings.[9,10] However, heterogeneity in burn characteristics, collagen products, study designs, and outcome measures limits the generalizability of existing evidence.[1,10] Moreover, high-quality prospective data from Indian tertiary-care centers remain limited, particularly regarding cost-effectiveness and functional outcomes in resource-constrained healthcare settings.[1]

Selection of an appropriate dressing in low- and middle-income countries requires balancing clinical efficacy with affordability and healthcare resource utilization.[1,2] Although collagen dressings may have a higher initial acquisition cost than conventional silver sulfadiazine, they may substantially reduce overall treatment expenditure by decreasing dressing frequency, nursing workload, analgesic requirements, wound infection, and duration of hospitalization while facilitating earlier return to normal activities.[9,10] Consequently, evaluation of both clinical effectiveness and economic impact is essential for optimizing burn-care protocols.

Against this background, the present prospective comparative study was undertaken to evaluate the effectiveness of collagen sheet dressing compared with conventional 1% silver sulfadiazine (SSD) dressing in patients with partial-thickness burns involving the upper limb. The primary outcomes included pain intensity and time to complete wound epithelialization, whereas secondary outcomes included wound infection, scar quality, dressing frequency, and overall treatment cost. Pain assessment was performed using the Visual Analogue Scale (VAS), a validated instrument widely used in clinical pain research.[11] Scar quality was assessed using established clinical criteria based on pigmentation, pliability, and overall cosmetic appearance, consistent with validated scar assessment methods.[12]

We hypothesized that collagen sheet dressing would provide superior clinical outcomes and improved cost-effectiveness compared with conventional silver sulfadiazine dressing, thereby supporting its wider use in the management of partial-thickness burns.

METHODS

Study design

This prospective comparative observational study was conducted in the Department of Plastic and Reconstructive Surgery, Christian Medical College, Ludhiana, Punjab, India, over a 17-month period from May 2020 to September 2021. The study protocol was approved by the Institutional Ethics Committee before commencement of the study (Approval No. IECCMCL/05-2932020/Apprvl-M.Ch THESIS/PlasSurg), and written informed consent was

obtained from all participants in accordance with the ethical principles of the Declaration of Helsinki.[13]

Study population

A total of 60 consecutive adult patients presenting with partial-thickness burns involving one or both upper limbs were enrolled. Patients were allocated into two treatment groups according to the dressing modality used.

Group I was collagen sheet dressing (n=30); group II was conventional 1% silver sulfadiazine (SSD) dressing (n=30).

During follow-up, one patient from each group was lost, resulting in a final study population of 58 patients.

Inclusion criteria

Patients fulfilling all of the following criteria were included: age ≥18 years; partial-thickness thermal burns involving one or both upper limbs; presentation within an appropriate time after injury for definitive wound management; hemodynamic stability following initial burn resuscitation; ability and willingness to provide written informed consent and comply with follow-up visits.

Exclusion criteria

Patients with any of the following conditions were excluded: full-thickness burns; electrical or chemical burns; burns requiring immediate excision and skin grafting; significant systemic illness likely to impair wound healing (eg, uncontrolled diabetes mellitus, immunosuppression, severe peripheral vascular disease); known hypersensitivity to collagen products; refusal to participate or inability to complete follow-up.

Treatment protocol

Group I: Collagen sheet dressing

Following clinical assessment, wound cleansing, and appropriate debridement under aseptic conditions, sterile collagen sheets were applied directly to the burn wound. The collagen dressing was left undisturbed until spontaneous separation following complete epithelialization or removed only if clinically indicated because of infection or dressing displacement. Repeat application was performed only when necessary.[8,9]

Group II: Conventional silver sulfadiazine dressing

Patients allocated to the control group received topical 1% silver sulfadiazine cream, which was uniformly applied over the burn surface and covered with sterile gauze. Dressings were changed daily or earlier if clinically indicated according to standard burn-care protocols.[2,6]

Standard care

All patients received identical supportive management, including: initial burn resuscitation according to established burn management principles; adequate analgesia; tetanus prophylaxis; nutritional support; antibiotic therapy only when clinically indicated; early physiotherapy and range-of-motion exercises to preserve upper-limb function.[2,7,14]

Outcome measures

Patients were evaluated on day 1, day 7, day 14, day 21, and day 28 after initiation of treatment.

Primary outcomes

The pain intensity measured using the Visual Analogue Scale (VAS).[11] The primary outcome was the time to complete wound epithelialization.

Secondary outcomes

The secondary outcomes were the number of dressing changes; clinical wound infection; scar quality; overall treatment cost; and pain assessment

Pain intensity was assessed using a 10-point VAS, where 0 represented no pain and 10 represented the worst imaginable pain. Pain scores were recorded on days 1, 2, 7, and 14 by trained clinicians using a standardized assessment protocol.[11]

Wound healing assessment

Complete wound healing was defined as 100% epithelialization without residual raw areas or the need for additional wound coverage. Healing time was calculated as the number of days from initiation of treatment to complete epithelialization.[4,10]

Infection assessment

Patients were clinically evaluated for evidence of wound infection, including purulent discharge; increasing erythema; local warmth; edema; foul odor; and delayed wound healing.

Patients with suspected infection underwent microbiological evaluation when indicated and received antimicrobial therapy according to institutional protocols.[7]

Scar assessment

Scar quality was evaluated following complete wound healing based on pigmentation, pliability, surface characteristics, and overall cosmetic appearance. Scars were categorized as satisfactory or unsatisfactory according to validated scar assessment methods.[12]

Statistical analysis

Data were entered into Microsoft Excel and analyzed using IBM SPSS Statistics (IBM Corp., Armonk, NY, USA).

Continuous variables were expressed as mean ± standard deviation (SD), whereas categorical variables were presented as frequency and percentage.

Comparisons between groups were performed using independent Student's t test for continuous variables and Chi-square test or Fisher's exact test for categorical variables.

All statistical tests were two-tailed, and a p value <0.05 was considered statistically significant.

RESULTS

Patient enrollment

Between May 2020 and September 2021, 60 consecutive patients with partial-thickness burns involving the upper limb were enrolled. One patient from each treatment group was lost to follow-up, leaving 58 patients for the final analysis. The study flow is presented in Figure 1.

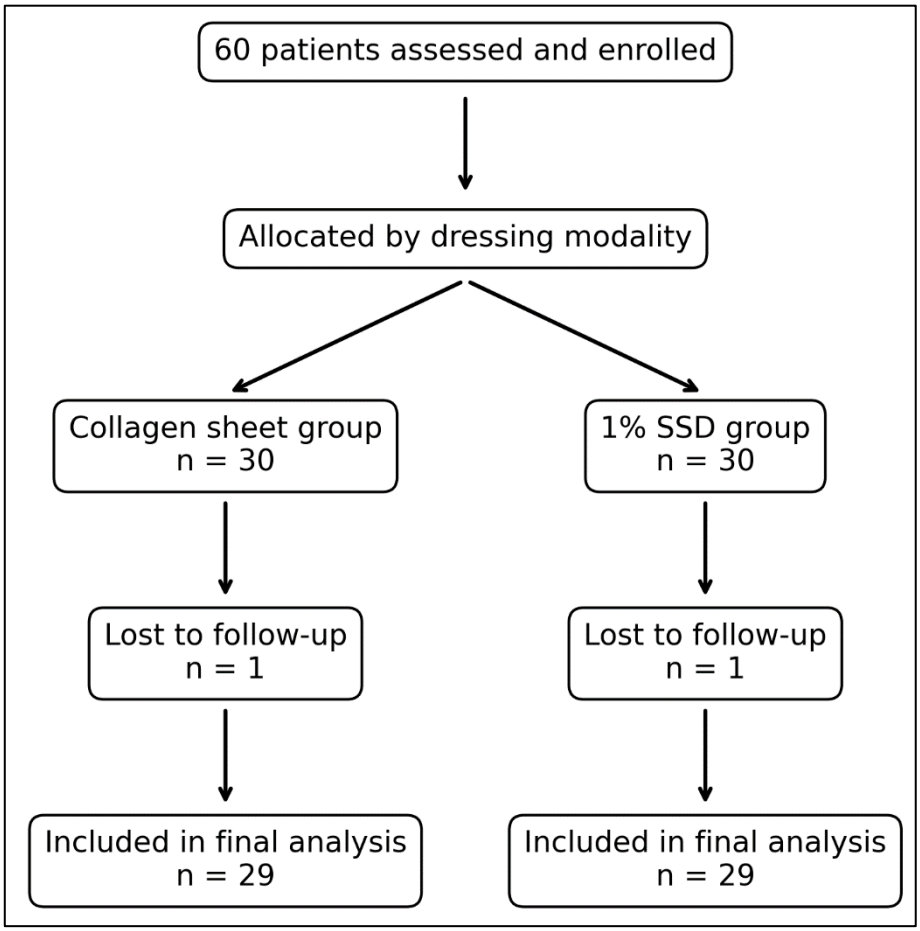

Figure 1: Flow diagram of patient enrollment, allocation by dressing modality, loss to follow-up, and final analysis.

Table 1: Baseline demographic and burn characteristics.

Characteristics	Collagen (n=30)	SSD (n=30)
	N (%)	N (%)
Mean age, years (mean±SD)	25.72±13.99	33.90±13.02
Age <20 years	7 (23)	3 (10)
Age 21–30 years	13 (43)	12 (40)
Age 31–40 years	6 (20)	6 (20)
Age 41–50 years	4 (13)	6 (20)
Age 51–60 years	0 (0)	3 (10)
Female	7 (23)	3 (10)

Continued.

Characteristics	Collagen (n=30)	SSD (n=30)
Male	23 (77)	27 (90)
Flame burn	23 (77)	25 (83)
Scald burn	7 (23)	5 (17)
Accidental injury	30 (100)	29 (97)
Homicidal injury	0 (0)	1 (3)
TBSA burned, % (mean ± SD)	28.90±12.93	33.33±12.27
Left upper limb	16 (53)	11 (37)
Right upper limb	14 (47)	19 (63)

Table 2: Dressing requirements and pain scores.

Outcomes	Collagen (n=29)	SSD (n=29)	P value
Number of dressing changes (mean±SD)	1.03±0.19	9.17±3.11	<0.001
VAS Day 1 (mean±SD)	4.53±1.20	5.97±1.35	
VAS Day 2 (mean±SD)	2.14±1.06	4.66±1.32	
VAS Day 7 (mean±SD)	1.38±0.73	3.59±1.30	
VAS Day 14 (mean±SD)	0.52±0.63	3.03±0.91	

Table 3: Time to complete wound epithelialization.

Outcomes	Collagen (n=29)	SSD (n=29)	P value
Healing time, days (mean±SD)	13.10±3.79	19.41±7.06	<0.001

Table 4: Wound infection and early scar quality.

Outcomes	Collagen (n=29)	SSD (n=29)
	N (%)	**N (%)**
Wound infection: Yes	4 (14)	11 (38)
Wound infection: No	25 (86)	18 (62)
Good scar quality	25 (86)	16 (55)
Poor scar quality	4 (14)	13 (45)

Table 5: Comparison of overall treatment cost.

Outcomes	Collagen (n=29)	SSD (n=29)	P value
Treatment cost, ₹ (mean±SD)	2716.55±794.19	3211.38±1027.45	0.045

Note: Baseline characteristics are shown for the 30 patients initially enrolled in each group. Treatment outcomes are shown for the 29 patients per group included in the final analysis.

Baseline characteristics

Baseline demographic and burn characteristics are summarized in Table 1.

Most patients were young adults aged 21-30 years. The mean age was 25.72±13.99 years in the collagen group and 33.90±13.02 years in the silver sulfadiazine (SSD) group. Male patients predominated in both groups, accounting for 77% and 90% of participants in the collagen and SSD groups, respectively. Flame burns were the most common mechanism of injury, representing approximately four-fifths of all burns, and the majority of injuries occurred accidentally.

The mean age differed significantly between groups (25.72±13.99 years in the collagen group versus 33.90±13.02 years in the SSD group; p=0.022). However, the categorical age distribution, sex, burn mechanism, mode of injury, side of involvement, and percentage of total body surface area burned did not differ significantly between groups.

Dressing requirements

Patients treated with collagen sheet dressing required significantly fewer dressing changes than those managed with conventional SSD dressing.

The mean number of dressing changes is summarized in Table 2.

Collagen group was 1.03±0.19; SSD group was 9.17±3.11 This difference was highly statistically significant (p< 0.001) (Table 2).

Nearly all patients in the collagen group required only a single dressing application until complete epithelialization, whereas patients in the SSD group underwent repeated daily dressing changes throughout the treatment period.

Pain assessment

Pain scores decreased progressively during follow-up in both treatment groups. However, patients treated with collagen sheet dressing consistently reported significantly lower pain scores at each assessment interval.

A significant reduction in pain was evident from the second postoperative day and persisted throughout follow-up (Table 2).

Wound healing

Complete wound epithelialization occurred significantly earlier in the collagen group than in the SSD group.

The mean healing time was: collagen group: 13.10±3.79 days; SSD group: 19.41±7.06 days. The difference of more than six days was statistically significant (p<0.001) (Table 3).

Patients treated with collagen sheet dressing demonstrated earlier wound closure and more rapid epithelial regeneration than those receiving conventional SSD dressing.

Wound Infection

Clinical wound infection occurred less frequently in patients treated with collagen sheet dressing.

The proportion of patients remaining free from wound infection is summarized in Table 4.

Collagen group was 86% and SSD group was 62%.

Although all infections responded to appropriate antimicrobial therapy, the collagen group demonstrated a lower incidence of wound infection during the study period.

Scar quality

Scar assessment following complete wound healing demonstrated superior cosmetic outcomes in the collagen group.

Good-quality scars were observed in the proportions summarized in Table 4.

Collagen group was 86% and SSD group was 55%.

Patients managed with collagen sheet dressing exhibited better pigmentation, greater scar pliability, and a more satisfactory overall cosmetic appearance during early follow-up.

Cost analysis

Despite the higher initial acquisition cost of collagen sheets, the overall treatment cost was significantly lower in the collagen group.

The mean treatment cost is summarized in Table 5.

Collagen group was ₹2716.55±794.19 and SSD group was ₹3211.38±1027.45

The reduction in overall treatment cost was primarily attributable to: fewer dressing changes; reduced nursing time; lower analgesic requirements; shorter healing duration; and decreased healthcare resource utilization.

Summary of major findings

Compared with conventional 1% silver sulfadiazine dressing, collagen sheet dressing was associated with: significantly fewer dressing changes; lower pain scores throughout follow-up; faster wound epithelialization; lower incidence of wound infection; superior early scar quality; and lower overall treatment costs.

Overall, collagen sheet dressing demonstrated superior clinical outcomes compared with conventional silver sulfadiazine dressing in the management of partial-thickness burns involving the upper limb.

DISCUSSION

Burn injuries continue to represent a major cause of morbidity worldwide, particularly in low- and middle-income countries where limited healthcare resources often influence the selection of wound dressings.[1-3] The primary objectives of burn wound management are rapid wound closure, prevention of infection, effective pain control, preservation of function, and achievement of acceptable cosmetic outcomes.[2,4] In recent years, biological dressings such as collagen sheets have gained increasing attention because they provide a physiological wound environment that promotes tissue regeneration while reducing the need for repeated dressing changes.[8,9]

The present prospective comparative study demonstrated that collagen sheet dressing was associated with significantly fewer dressing changes, lower pain scores, earlier wound epithelialization, reduced wound infection, superior scar quality, and lower overall treatment costs

compared with conventional 1% silver sulfadiazine (SSD) dressing. These findings are consistent with previous clinical studies and systematic reviews supporting collagen-based dressings for partial-thickness burns.[10]

One of the most clinically relevant findings of the present study was the marked reduction in dressing frequency. Nearly all patients treated with collagen required only a single application until complete epithelialization, whereas patients receiving SSD required repeated daily dressings. Frequent dressing changes increase nursing workload, healthcare costs, patient discomfort, and repeated trauma to newly formed epithelium.[6,10] Singh et al. similarly reported that collagen dressings significantly reduced the number of dressing changes while improving patient comfort and accelerating healing.[9]

Pain control remains a major determinant of patient satisfaction during burn treatment. Patients treated with collagen dressings experienced significantly lower pain scores throughout follow-up. This improvement is likely related to protection of exposed dermal nerve endings, maintenance of a moist wound environment, and elimination of repeated daily dressing changes.[8,9] Better pain control facilitates early mobilization, improves compliance with physiotherapy, and enhances overall recovery. Similar reductions in pain have been reported in systematic reviews comparing biological dressings with conventional SSD therapy.[10,15]

Early epithelialization is one of the strongest predictors of successful burn management because delayed wound closure is associated with increased infection, hypertrophic scarring, prolonged hospitalization, and functional impairment.[3,4] In the present study, patients receiving collagen dressings achieved complete epithelialization approximately six days earlier than those treated with SSD. Collagen acts as a three-dimensional extracellular matrix supporting fibroblast migration, angiogenesis, keratinocyte proliferation, and tissue remodeling, thereby promoting faster wound healing.[4,8] These findings closely parallel those reported by Singh et al., who demonstrated significantly faster healing with collagen dressings than with conventional wound dressings.[9]

The lower incidence of wound infection observed in the collagen group is another important finding. Although collagen itself has no intrinsic antimicrobial activity, it functions as a biological barrier that minimizes environmental contamination while maintaining an optimal wound microenvironment. Earlier epithelialization further reduces the period during which bacterial colonization may occur.[7] Previous reviews have shown that routine SSD therapy does not consistently reduce infection rates and may delay wound healing because of cytotoxic effects on keratinocytes and fibroblasts.[5,6]

Scar quality was superior among patients treated with collagen sheets. Rapid epithelialization, reduced inflammation, and preservation of the extracellular matrix contribute to improved scar maturation.[8] Since upper-limb burns frequently result in functional limitation secondary to hypertrophic scarring and contracture formation, improved scar quality has important implications for long-term rehabilitation. Scar assessment in future studies should incorporate validated instruments such as the Vancouver Scar Scale or the Patient and Observer Scar Assessment Scale (POSAS).[12]

An important finding of this study was the reduction in overall treatment cost despite the higher initial purchase price of collagen sheets. Although collagen dressings are more expensive at the time of application, reductions in dressing frequency, nursing time, analgesic requirements, outpatient visits, and healing duration resulted in lower overall expenditure.[10] These findings are particularly relevant in resource-limited healthcare settings, where cost-effectiveness is an important determinant of treatment selection.[1]

The findings of the present study are consistent with contemporary systematic reviews questioning the routine use of silver sulfadiazine for uncomplicated partial-thickness burns. Heyneman et al. concluded that SSD offers no clear advantage over several modern dressing materials and may delay epithelialization.[6] Similarly, Wasiak et al. reported that newer biological and occlusive dressings generally achieve superior healing outcomes with fewer dressing changes and improved patient comfort.[10] These observations further support the use of collagen sheet dressing as an effective alternative to conventional SSD therapy.

Strengths

The present study prospectively evaluated several clinically relevant outcomes, including pain, wound healing, infection, scar quality, dressing frequency, and treatment cost using standardized follow-up protocols. Simultaneous assessment of both clinical effectiveness and economic impact enhances the applicability of these findings to routine burn care.[1,2]

Limitations

The study has several limitations. It was conducted at a single tertiary-care center with a relatively small sample size, limiting generalizability. Treatment allocation was observational rather than randomized, introducing the possibility of selection bias. Follow-up was limited to early wound healing and did not evaluate long-term scar maturation or functional outcomes. Future multicenter randomized controlled trials with larger sample sizes and longer follow-up are required to validate these findings.

CONCLUSION

In this prospective comparative study of adults with partial-thickness upper-limb burns, collagen sheet dressing was associated with fewer dressing changes, lower pain scores, earlier complete epithelialization, fewer wound infections, better early scar quality, and lower overall treatment costs than conventional 1% silver sulfadiazine dressing. Although the observational design, single-centre setting, modest sample size, and short follow-up limit causal interpretation and generalizability, the findings add clinically relevant comparative evidence from an Indian tertiary-care setting by evaluating patient comfort, healing, infection, early scar outcome, and treatment cost together. This integrated assessment advances understanding of the potential role of collagen sheets as an effective and resource-conscious dressing option for selected patients with partial-thickness upper-limb burns.

Recommendations

Larger multicentre randomized controlled trials with longer follow-up are recommended to confirm these findings. Future studies should use standardized burn-depth and scar-assessment tools, include long-term functional outcomes, and undertake a prospective health-economic evaluation before routine adoption across different healthcare settings.

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