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The Effect of a Hydrogel Copper Gauze on the Healing of Third-Degree Burns Using a Porcine Model

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Abstract

Introduction: Burn wound injury can produce substantial morbidity and mortality for both civilians and military personnel.[1] Third-degree burns include full thickness destruction of both the epidermis and dermis that results in the develop of scars and contractures.[2] Copper has been previously used for it's antimicrobial and wound healing effects.[3,4] The present study investigated the ability of two novel hydrogel copper gauze prototypes to enhance the healing of third degree burns using a porcine model.[5]

Methods: Seventy-two (72) third degree burn wounds were created on pig, within 20 minutes after wounding all wounds were treated one of the following treatments: 1) Hydrogel Gauze with Copper H1-D (Copper H1-D)^; 2) Hydrogel Gauze with Copper H1-B (Copper H1-B)+; 3) Gelling Fiber Dressing with silver (GFD-Ag)*; or 4) Untreated Control●. All wounds were covered with a polyurethane film dressings and histologically assessed on days 10, 14 and 21 post treatment.

Results: Copper H1-D showed a significant ($p \leq 0.05$) increase in the healing at all assessment days compared to GFD-Ag, showing the highest healing percentage (84.8%) on day 21 ($p \leq 0.05$) compared to all treatment groups. On day 10, a significant ($p \leq 0.05$) increase in wound healing was observed as well as with Copper H1-B compared to wounds treated with GFD-Ag.

Discussion: This study demonstrates both Hydrogel Gauze with Copper prototypes resulted in an epithelialization increase compared to GFD-Ag, having Copper H1-D as the best treatment tested among the others. These significant results demonstrate the ability of the copper treatments to enhance the healing, showing promising clinical implications, especially for third degree burn patients.

^ + Hydrogel Gauze with Copper prototypes H1-D and H1-B (iFyber, LLC Ithaca, NY, USA); * Kerracel™ Ag (3M, St. Paul, MN USA); ● Tegaderm™ polyurethane film dressings (3M, St. Paul, MN USA)

Introduction

According to the World Health Organization (WHO), third degree burns are the cause for approximately 180,000 deaths every year around the world.[6] Due to the necessary skin reconstruction after a third degree burn, the range of motion and complete function can be negatively impacted.[7] It is paramount to have immediate and effective therapies to not only reduce infection but also improve the healing for burns. [2] In the following study we evaluate a novel copper dressing to stimulate the healing of burn wounds.

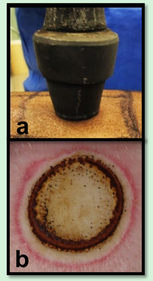
Materials and Methods

1. Experimental Animal:

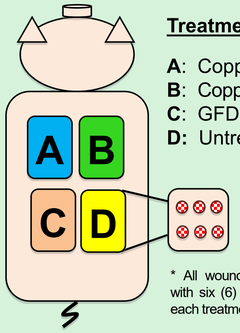
Swine were used as our experimental animal due to the morphological, physiological, and biochemical similarities between swine skin and human skin.[8] Three (3) animals were used for this study.

2. Wounding Technique:

- A branding iron (L & H Manufacturing Company Mandan – photo a) set to 300ºC by 15 seconds.
- Twenty-four (24) 3rd degree burn wounds with a 27mm diameter and a depth of approximately 3mm (photo b)
- A total of seventy-two (72) wounds were examined.



3. Experimental Design:



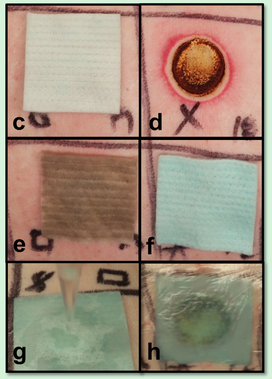
Treatment Groups*

A: Copper H1-D^
B: Copper H1-B+
C: GFD-Ag*
D: Untreated Control●

* All wounds were randomized with six (6) wounds assigned to each treatment group (4).

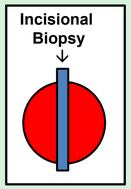
4. Treatment Regimen:

- Wounds were treated 20 minutes after wound creation (photos c, e and f).
- Untreated Control wounds (photo d) were only covered with a polyurethane film dressing.
- All dressings were moistened with sterile saline water using a micropipette (photo g).
- After treatment application all treated areas were covered with a polyurethane film dressing (photo h).
- All dressings were secured in place with tape and Coban.



5. Histology Assessment:

On days 10, 14 and 21, six (6) incisional biopsies per group were taken from the center of each wound. Biopsies were placed in formalin then stained with hematoxylin and eosin (H&E). One section per block were analyzed. The specimens were blindly evaluated and examined for the following parameters to determine a potential treatment response:



1. Percent of wound epithelialized (%). Measurement of the length of the wound surface that has been covered with epithelium.
2. Epithelial thickness (cell layers µm). The epithelial thickness may vary from area to area within the biopsy. The thickness of the epithelium in µm will be measured on five equal distance points from each other in the biopsy and averaged.
3. White cell infiltrate. Measured by the presence of sub-epithelial mixed leukocytic infiltrates. Mean Score: 1 = absent, 2 = mild, 3 = moderate, 4 = marked, 5 = exuberant.
4. Granulation Tissue Formation. The approximate amount of new granulation tissue formation (dermis) was graded as follows: 0: <1%, 0.5: 1-10%, 1: 11-30%, 2: 31-50%, 3: 51-70%, 4: 71-90%, 5: >90%

6. Statistical Analysis:

- A one-way analysis of variance (ANOVA) was used for statistical analysis for the microbiology. A p-value of less than (≤) 0.05 was considered significant.

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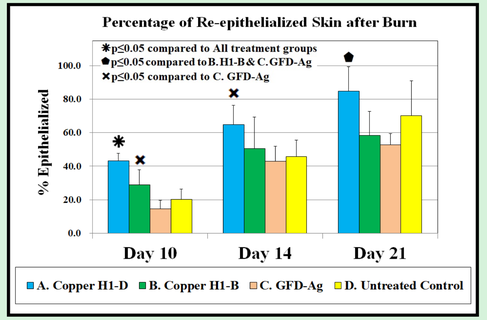
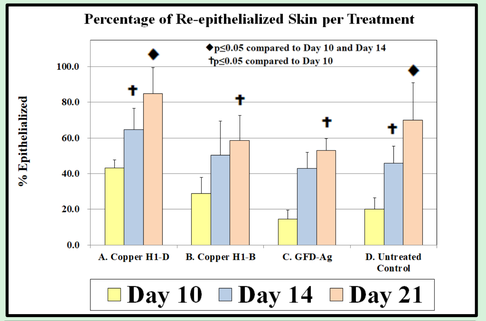
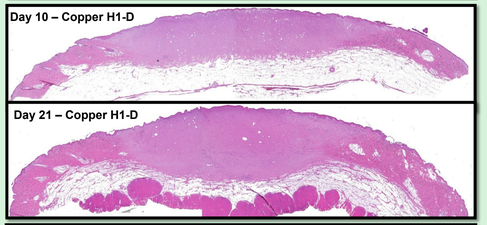
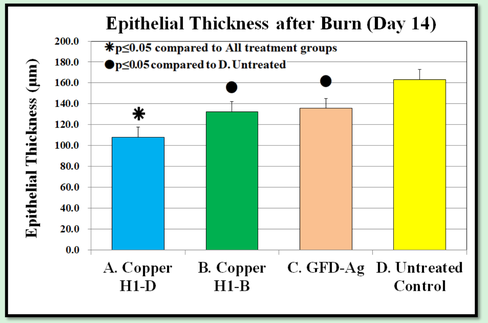
Results



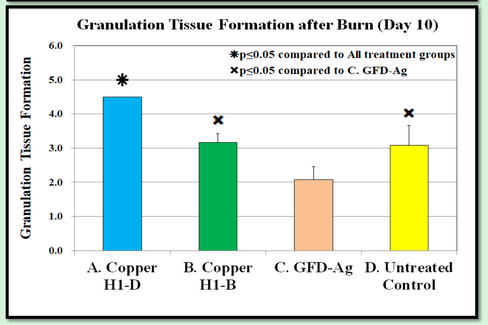
- Wounds treated with Copper H1-D exhibited significantly ($p \leq 0.05$) higher percentage of newly formed re-epithelialized skin than GFD-Ag on every assessment day.
- Only day 14, only wounds treated with Copper H1-D (64.8%) were significantly ($p \leq 0.05$) higher than GFD-Ag (42.9%). By the end of the study, only Copper H1-D reached percentages as high as 84.8%, while also being significantly ($p \leq 0.05$) higher than both Copper H1-B and GFD-Ag.
- Copper H1-D treated wounds reaching over 43% of re-epithelialization on day 10. By day 21 (11 days later), almost twice as much newly formed epidermis was observed.







- On day 14, Copper H1-D had a significantly lower ($p \leq 0.05$) epithelial thickness measurements lower than all groups. Copper H1-B and GFD-Ag were significantly ($p \leq 0.05$) lower than Untreated Control.



- On day 10, Copper H1-D treated wounds had significantly ($p \leq 0.05$) higher granulation tissue than all other groups. GFD-Ag treated wounds had a significantly ($p \leq 0.05$) lower score than other treatment groups.
- White cell infiltration (WCI) results exhibited all treatments to have significantly ($p \leq 0.05$) lower scores than Untreated Control. By the end of the study, there was no significant differences in WCI scores among all groups.

Conclusions

- Copper H1-D exhibited superior wound healing activity on third degree wounds when compared against the other groups in this study. The initial rate of re-epithelialization provided by Copper H1-D was impressive with re-epithelialization percentages more than twice as GFD-Ag and Untreated Control. Copper dressings showed higher granulation tissue scores than GFD-Ag. Use of new technologies as this dressing open a promising future in the treatments of patients with burn injuries.

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