Topical Application of a Novel Powdered Scaffold for Rapid Treatment of Skin Injuries

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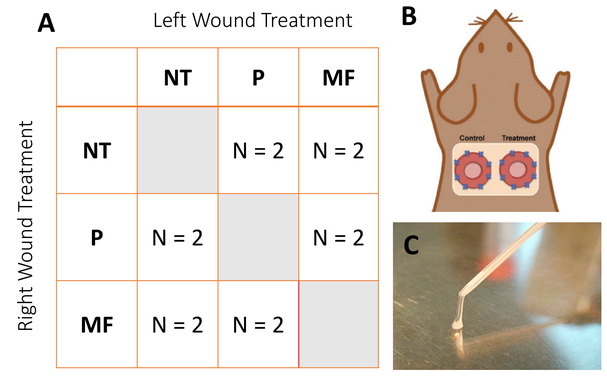
Abstract

Wound repair is a complex process beginning with the formation of a temporary scaffolding to allow cell migration into the wound bed. A disruption or improper completion of the wound healing process can cause chronic wounds and create a large burden on the public healthcare system. An in-situ forming skin substitute developed by our lab, Mesh-Fill (MF)[1], has been shown to be effective in speeding the wound repair process. However, MeshFill is limited in its application to deep wounds, and requires reconstitution with a solvent. Our goal was to investigate other uses for MF, notably whether it could be used as a powder (P), whereby future applications may include superficial wounds such as that in burn patients. Here, we examined the efficacy of P compared to the standard reconstituted gel MF and to no treatment (NT). Results showed that P conditions had greater wound healing at days 7 and 14, compared to NT, and had faster wound closure time. No significant difference between P and MF was found for either outcomes. Additionally, our results suggest that epidermis formation was more effective in P and MF conditions compared to NT. Taken together, these results suggest that P could provide an alternative use to traditional MF.

Material and Methods

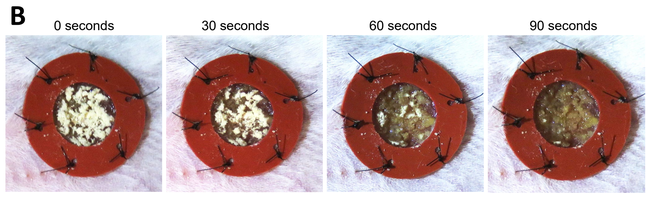
1. Two 6mm punch wound were applied to CD-1 mice (**Figure 1B**), and each mouse was randomized to a treatment condition pair (**Figure 1A**)
2. MeshFill was either reconstituted with distilled water for standard Mesh-Fill (MF) (**Figure 1C**) or kept as dehydrated powder (P).
3. Treatment application occurred twice: between days 0 and 2; and between days 3 and 6
4. Wounds were photographed bi-weekly, and measured as the ratio of wound area to inner splint area
5. Wounds were considered closed once epithelialized.
6. Masson's trichrome and H&E stain analysis to examine re-epithelialization were performed on select samples
7. Epidermis thickness (ET) was measured as previously reported through ImageJ[(3)]

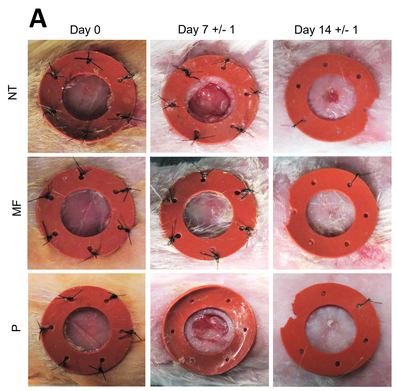
Figure 1.



Results

Figure 2. (A) MF and P treatment visually improved the healing of wounds over 14 days compared to no treatment. Representative samples providing a visual overview of the healing process across treatment conditions on days 0, 7 (+/-1), and 14 (+/1). **(B) MeshFill Powder incorporates into the wound within 2 minutes.** Overview of the time it takes for the P to integrate into the wound bed. MeshFill P was found to incorporate into the wound as a result of humidification through natural wound fluids.





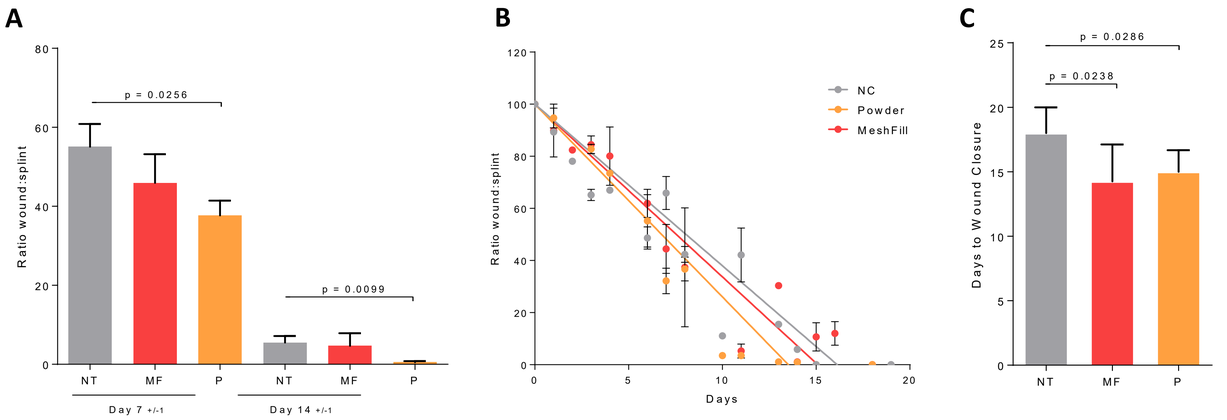


Figure 3. (A) Powder-treated wounds had significantly smaller wound sizes at days 7(+/-1) and 14(+/-1) compared to NT. No significant difference was found between MF and P treatment. **(B) Linear Regression illustrates the approximate progression of wound healing with the P treatment group healing at the fastest rate.** Includes pooled values of all wound measurements taken for each treatment condition.. An ANCOVA was performed indicating that there is a significant difference between slopes. **(C) P and MF wounds healed faster than NT wounds.** On average, the P treatments healed 17% faster than the NT control, and the MF treatments healed 21% faster than the NT control. No significant difference was found between the MF and P treatments. All mice for which we had a date depicting full wound closure were included.

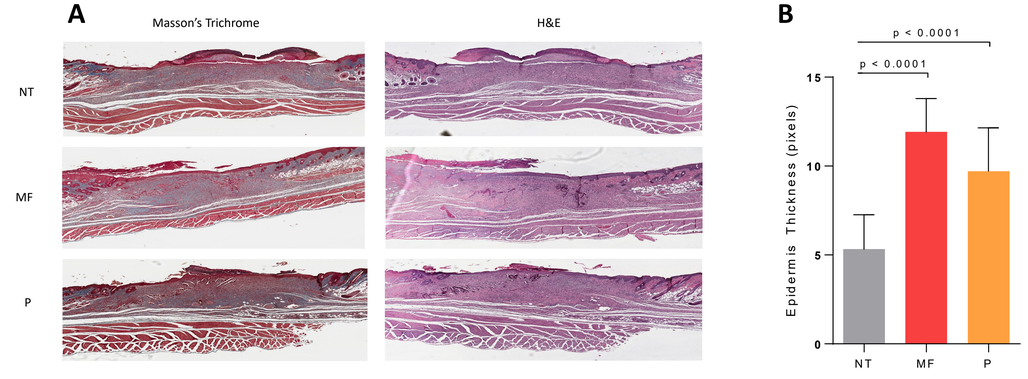


Figure 4. (A) Epidermis reformation is more established in MF and P wounds than in NT. H&E and Masson's trichrome stains were completed to examine the general histology of the three treatment groups. **(B) Healing outcome defined by epidermis thickness were more favourable for MF and P wounds than NT wounds.** Healing outcome as measured through epidermis thickness (ET) from H&E histology stains.

Conclusion

- Results suggest that the application powdered Mesh-Fill accelerates the healing process of in a murine model at a rate comparable to the standard reconstituted Mesh-Fill, and significantly faster than no treatment
- Additionally, our results suggest that epidermis reformation following wounding is more efficient in MF and P conditions
- Our approach provides evidence that powdered Mesh-Fill may be an effective alternative agent to promote wound healing in superficial wounds.

Future Applications

- Explore the molecular method of action on wound healing of powdered Mesh-Fill compared to reconstituted Mesh-Fill.
- Assess whether powdered MeshFill can offer promising results in human populations with superficial wounds, such as that of burn patients

References

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icord International Collaboration on Repair Discoveries