Thread Size and Polymer Composition Of 3D Printed and Electrospun Wound Dressings Affect Wound Healing Outcomes in An Excisional Wound Rat Model

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Statement of Purpose: Thread size and polymer composition are critical properties to consider for achieving a positive healing outcome with a wound dressing. 3D printed scaffolds and electrospun mats both offer distinct advantages as replaceable wound dressings. This research aims to determine if thread size and polymer compositions of scaffolds affect skin wound healing outcomes, an aspect that has not been adequately explored.

Methods: (materials and analytical procedures used) Four polyesters were synthesized by DIC mediated polymerization of four pendant-functionalized diols and Boc-L-glutamic acid. The polyesters were purified, characterized and blended with 50%PCL prior to fabrication into electrospun mats or 3D printed scaffolds. Extrusion-based direct-write 3D printing was used to print 0/90° crosshatch scaffolds with filament diameters of ~400 µm. Electrospun mats of the polyesters were fabricated with fibers dimensions ~4 µm.

An excisional skin wound rat model was used to test the effect of thread size or polymer composition on wound healing in vivo. Splinted wounds were treated with either the electrospun mats or 3D printed scaffolds and replaced every two days. Wound closure rates were analyzed by imaging and immunohistochemistry. Four aspects of wound healing were measured including reduction in width of the wound bed, angiogenesis, epidermal thickness and granulation tissue area. Blood vessel density within the granulation tissue was used as a measurement of angiogenesis.

Results: Using a modular polymer platform, four polyester direct-write 3D printed scaffolds and electrospun mats were fabricated into wound dressings. The dressings were applied to splinted, full thickness skin wounds in an excisional wound rat model and evaluated against control wounds to which no dressing was applied.

Wound closure rates and reduction of the wound bed width were not affected by thread size or polymer composition. However, epidermal thickness was larger in wounds treated with electrospun dressings and was slightly affected by polymer composition. Two of the four tested polymer compositions lead to delayed reorganization of granulation tissue. Moreover, enhanced angiogenesis was seen in wounds treated with 3D printed dressings compared to those treated with electrospun dressings. The results from this study can be used to inform choice of dressing architecture and polymer compositions to achieve positive wound healing outcomes.

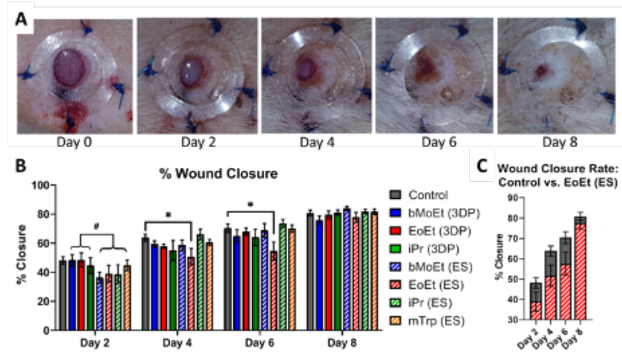

Figure 1. Effect of thread size and polymer composition on wound closure. A) Representative image tracking wound closure over 8 days. B) Wound closure as a percentage of the original wound area for each dressing architecture. C) Wound closure rate of control wounds compared to wounds treated with the electrospun EoEt dressing, showing the difference in wound closure kinetics of this dressing compared to others.

Conclusions: By investigating the roles of polymer composition and thread size in wound healing, positive healing outcomes can be achieved through improved dressing design. In this study, the four polyesters were fabricated into electrospun mats or 3D printed scaffolds and analyzed in an excisional wound rat model. The effects of thread size and polymer composition were investigated. Thread size played a significant role in affecting the epidermal thickness and the blood vessel density of the wounds. Electrospun mats lead to thicker epidermises than both 3D printed scaffolds and control wounds. Due to larger pore size, the 3D printed scaffolds lead to increased angiogenesis which can play a pivotal role in bringing nutrients and oxygen to the wound site. Polymer composition slightly affected epidermal thickness. Overall, thread size plays a significant role in healing outcomes. Polymer composition plays a less significant role overall, but the effects of polymer composition were amplified when electrospun.

References:

Nun, N et al, Biomacromolecules, 2020, 21, 4040