

Chitin/Chitosan-Silver Nanoparticles as Dressing Materials for Donor Site Wounds

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Introduction: Split-thickness skin grafting (STSG) is a common reconstructive surgical procedure when autologous skin tissue is required. It is performed for the treatment of patients with second and third degree burns, as well as patients suffering from diabetic ulcers and lymphedema. STSG creates a donor site wound, from which a thin layer of epidermis and dermis is harvested for autologous transplantation^[1]. Through our initial survey study involving 70 nurses, surgeons, therapists and researchers working in 31 burn and trauma centers across the southern USA, we have identified the most important requirements of a STSG wound dressing involve the need for: i) reduction in pain, ii) antibacterial properties, iii) non-adherence to the wound and iv) prevention of wound desiccation (Figure 1). Based on these results a fibrous hydrogel with the desired characteristics has been fabricated from β -chitin combined with silver nanoparticles and evaluated against commercially available products.

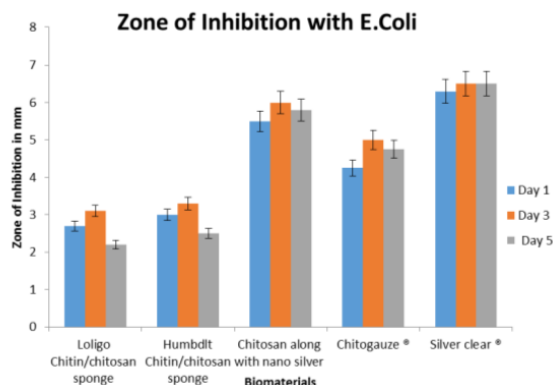


Figure 2: Zone of inhibition results for chitin/chitosan fibrous sponges, compared with silver nanoparticles and control dressing materials.

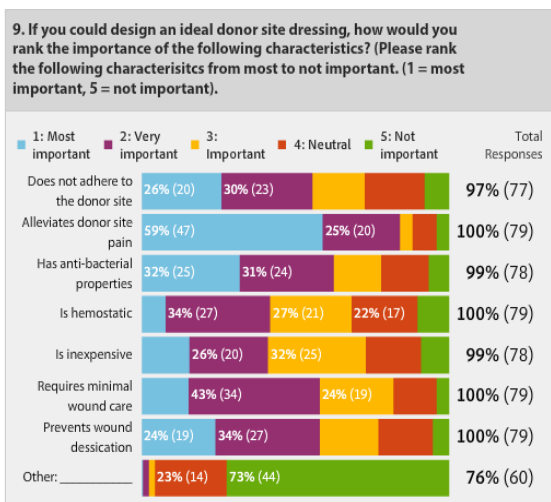


Figure 1: Results presented at Southern Burn Regional Conference 2013 highlighting desirable characteristics of dressings for treating donor site wounds after STSG.

Material and Methods: Two sources of β -chitin were found for this study. The pens from Pacific Ocean Humboldt squids were donated by Hopkins Marine Station, Stanford, CA, and pen samples of Atlantic loligo squid were donated by Harvard University (Boston, MA). Mixtures of chitin and chitosan were obtained from these squid pens utilizing methanol and calcium chloride solvents^[2]. Mixture of fibers and nanoparticles were freeze dried to obtain hydrogels. Ionic silver (Ag^{+2}) particles were added to the chitin/chitosan hydrogels so as to augment their antibacterial properties towards *Escherichia coli*. In order to determine their hemostatic properties fresh porcine whole blood samples were obtained from the NCSU College of Veterinary Medicine^[3].

Results: The bacteriostatic effect of the porous chitin/chitosan fibrous hydrogel structures was observed in comparison with the other dressing materials. The presence of silver ions generated a superior antibacterial effect compared to the chitin/chitosan materials, whose average zone of inhibition was observed to decrease after Day 3 (Figure 2).

The hemostatic response was associated with activation of platelets and leukocytes and the formation of fibrin. However, the timing and mechanism of thrombus formation was observed to depend on the presence of chitin/chitosan and/or nanosilver particles when in first contact with fresh whole blood (Figure 3).

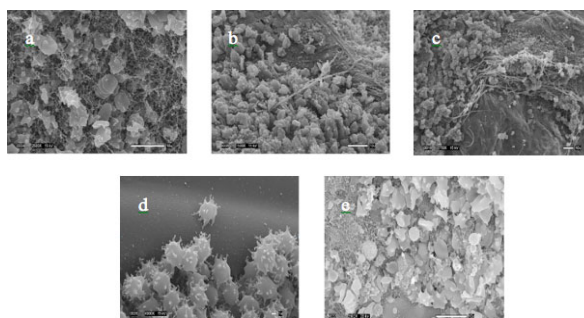


Figure 3: SEM photomicrographs (2,300x) showing different levels of activation with platelets, leukocytes and red blood cells. (a) Loligo chitin/chitosan fibers, (b) Humboldt chitin/chitosan fibers, (c) Silver nanoparticles together with chitin/chitosan, (d) Silverclear[®], (e) Chitogauze[™]. Fibrin formation is evident in images (b) and (c).

Conclusions: Figure 2 indicates that β -chitin/chitosan together with ionic silver provides a superior antibacterial effect compared to β -chitin/chitosan alone. In addition, it appears to provide a different cellular activation path, which affects the timing of thrombin formation and achieving hemostasis. Work is continuing to evaluate these and the other desirable clinical characteristics of wound dressings for donor site wounds following STSG.

References: [1]. Sibbald RG, Williamson D, Orsted HL, Campbell K, Keast D et al. Preparing the wound bed - debridement, bacterial balance, and moisture balance. *Ostomy Wound Manage* 2000; 45(11): 14-35.

[2]. Tamura, H, Nagahama H and Tokura S. "Preparation of chitin hydrogel under mild conditions." *Cellulose* 13.4 (2006): 357-364. [3]. Singh R, Chacharkar MP, and Mathur MP. "Chitin membrane for wound dressing application—preparation, characterisation and toxicological evaluation." *International Wound Journal* 5.5 (2008): 665-673.