Advancing the Science of Wound Bed Preparation for Chronic Wounds

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Wound healing is the result of dynamic interactive processes that begin at the moment of wounding and involve soluble mediators, many cell types, and extracellular matrices.[1] When a wound proceeds through an orderly and timely reparative process and results in a sustained restoration of anatomic and functional integrity, it has been labeled an acute wound.[2] Conversely, a chronic wound is one that has failed to proceed through an orderly and timely process to produce anatomic and functional integrity or has proceeded through the repair process without establishing a sustained anatomic and functional result. Therefore, it is important to understand the various events involved in wound healing in order to select the most appropriate wound treatment.[3]

Wound bed preparation is the management of a wound in order to accelerate endogenous healing or to facilitate the effectiveness of other therapeutic measures.[3] The concept of wound bed preparation has evolved to provide a systematic approach to removing the barriers to natural wound healing and enhancing the effects of wound therapies.[4] Dowsett and Ayello[5] applied the acronym TIME — tissue (nonviable or deficient), infection/inflammation, moisture (imbalance), and edge (nonadvancing or undermined) — as a simple way to assess the wound and the state of wound bed preparation. Spruce[6] suggested in a series of cases that the hydroconductive dressing, Drawtex (SteadMed Medical LLC, Ft. Worth, TX), could be used effectively within the wound bed preparation framework.

To be effective in wound bed preparation, a product would have to facilitate debridement of necrotic tissue and debris, decrease excessive wound exudate, decrease the tissue bacterial level, remove deleterious chemical mediators, and set the stage for acceleration of endogenous healing or wound closure by wound approximation, skin graft, or pedicle flap. Recently, data have been reported demonstrating that using Drawtex for wound treatment can accomplish each of the requirements for effective wound bed preparation.[7]

Removal of necrotic tissue, debris, and slough from the wound is the first step of wound bed preparation. This can be accomplished in multiple ways including surgical, enzymatic, mechanical, biological, and autolytic debridement.[8] Dressings act by providing either mechanical or autolytic debridement or a combination of the two. Wolvos[9] demonstrated the ability of Drawtex to remove necrotic debris and slough from chronic wounds using digital wound bed analyses (iCLR technology, powered by Elixr, Imago Care Ltd., England). The average area of necrotic tissue, debris, and slough removed in a series of patients was 36% in 1 week, 52% by week 2, and 77% in 3 weeks. In a series of eight patients with Buruli ulcers of the lower extremity, Treadwell and Macdonald[10] reported removal of necrotic tissue with the use of Drawtex dressings and compression.

Excessive exudate impedes healing and must be decreased for effective wound bed preparation. Wolvos[9] reported that Drawtex can remove up to 150 cc/hour of wound exudate. Wolcott and Cox[11] reported the advantages of the exudate removal by hydroconductive dressings were several-fold. Not only was the fluid removed, but also nutrients in the exudate that facilitate biofilm production are drawn off. Concomitant with the exudate removal, periwound maceration decreased.

A high tissue bacterial bioburden has been associated with a failure of wound healing.[12] The level of tissue bacterial bioburden that inhibits healing has been shown in multiple studies[12,13] to be $>10^5$ or at least 1×10^6 bacteria per gram of tissue. Such high levels of tissue bacteria can be present without clinical signs of infection and when present can deleteriously affect wound healing.[14] Attempts to control the tissue bacterial bioburden have been difficult. Systemically administered antibiotics do not effectively decrease the level of bacteria in a chronic granulating wound[15]; topical antimicrobials or antiseptics have been used, but many have cytotoxic effects on the wound.[16]

Drawtex can effectively draw bacteria from wound tissue into its fibers. Ortiz et al[17] demonstrated both in *in vitro* and *in vivo* models that Drawtex can draw methicillin-resistant *Staphylococcus aureus* (MRSA) from either an inoculated broth or an experimental burn wound eschar. Ochs et al[18] reported similar results in patients with chronic wounds; tissue biopsy bacterial counts decreased from 10^6 to 10^2 CFUs per gram of tissue while at the same time the bacterial counts in the Drawtex dressings increased up to 10^4 CFUs.

Chronic wounds have excessive inflammation, increased pro-inflammatory cytokines, increased proteases such as matrix metallo-proteinases (MMPs), and decreased growth factors.[19-21] Removing or decreasing the deleterious cytokines is an important aspect of wound bed preparation. Wendelken et al[22] demonstrated that Drawtex could draw MMP-9 from

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chronic wounds and transport the cytokine for a distance up to 7 cm from the wound. Such an effective transport away from the wound allows the wound to proceed to healing without the deterrent of MMP-9. Ochs et al[18] showed that both MMP-9 and MMP-1 were drawn out of chronic wounds dressed with Drawtex. They showed a decrease in tissue levels of the MMPs and a concomitant rise in the MMPs in the Drawtex dressings used to treat the wounds.

Although exact correlations with each aspect of wound bed preparation and spontaneous wound healing or wound closure by surgical means are difficult to document, data are available regarding the ability of a wound to heal once the bacterial bioburden is controlled. Establishing bacterial balance in a chronic wound by decreasing the tissue bacterial level to 10^5 or fewer CFUs per gram of tissue has been demonstrated to accelerate healing by secondary intention.[23] Similarly, wound closure by wound approximation, skin grafting, or pedicle flap has been demonstrated to be successful only when bacterial counts were at 10^5 or fewer CFUs per gram of tissue.[24-26] The fact that Drawtex has been demonstrated to decrease the wound bacterial bioburden suggests its ability to improve wound bed preparation should result in improved healing outcomes. The data reviewed here help explain the beneficial effects seen in the healing of wounds treated with this hydroconductive dressing.[6,9,10,11,22] ■

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