Use of a Nanoflex powder dressing for wound management following debridement for necrotising fasciitis in the diabetic foot

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ABSTRACT

This paper discusses the application of Nanoflex powder dressing for management of complex soft tissue wounds. A case report is presented detailing the management of a 43-year-old Native American woman with diabetes mellitus who required serial debridements for necrotising fasciitis. Following debridement, the patient was left with a large dorsal foot wound and was transitioned through multiple advanced wound healing modalities. Negative pressure wound therapy (NPWT) was initially utilised in the early postoperative setting to control drainage and to promote granulation tissue; the patient was subsequently transitioned to a Nanoflex powder dressing on postoperative day 4. She reported a decrease in pain associated with dressing changes when transitioned from NPWT to the use of Nanoflex powder dressing. We hypothesise that this pain reduction is the result of a light cooling effect of the exudate-controlling dressing and subsequent reduction in inflammation as well as the total contact nature of the dressing. Nanoflex powder dressings are a recently developed advanced wound healing modality with promise in the management of complex soft tissue wounds, both as a primary wound dressing as well as a delivery platform for analgesics, antimicrobials and pro-angiogenic compounds.

Key words: Wound healing • Diabetic foot • Nanoparticle • Dressing • Nanotechnology

INTRODUCTION

Management of the soft tissue wounds created following radical debridement in patients suffering from necrotising fasciitis can be difficult because of the magnitude and complexity of resultant soft tissue defects (1–6). In these cases, advanced wound care products and techniques such as negative pressure wound therapy (NPWT) are often used to stimulate wound healing and to promote formation of granulation tissue (7–9). This report presents the case of a 43-year-old Native American female with diabetes mellitus who presented to the emergency department following a 5-day history of constitutional symptoms as well as persistent hyperglycemia and a 'draining' wound along the medial aspect of the second digit in the first interspace of the left foot. Upon clinical exam, the patient was found to be grossly neurovascularly intact in the left

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Key Points

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- in these cases, advanced wound care products and techniques such as negative pressure wound therapy (NPWT) are often used to stimulate wound healing and to promote formation of granulation tissue
- this report presents the case of a 43-year-old Native American female with diabetes mellitus

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Key Points

- imaging studies showed the presence of subcutaneous emphysema in the second digit extending into the first interspace
- the patient was admitted to the hospital with a diagnosis of necrotising fasciitis and emergently underwent radical debridement of the left foot
- following initial debridement that included partial second ray resection and extensive debridement of the dorsal and plantar soft tissue, the patient was subsequently admitted to the hospital for parenteral antibiotics, pain management, and glycemic control
- NPWT therapy was initiated on postoperative day 1
- on postoperative day 3, the patient was returned to the operating room for further debridement
- following the secondary debridement, it was decided to change the therapy of choice to Nanoflex powder dressing with the intent of providing moisture control, decreased dressing changes, and stimulation of wound healing

lower extremity, with significant liquefactive necrosis of the soft tissues in the area of the second digit with proximal extension along the dorsum of the left foot to the level of the ankle. A review of the available laboratory data showed an acute leukocytosis with a WBC count of 21, blood glucose levels >300 mg/dl, and an HgBA1C of 12·0. Imaging studies showed the presence of subcutaneous emphysema in the second digit extending into the first interspace. The patient was admitted to the hospital with a diagnosis of necrotising fasciitis and emergently underwent radical debridement of the left foot. Following the initial debridement, the patient was referred to our foot clinic for further management of her complex left foot soft tissue wound.

CASE MANAGEMENT

Following initial debridement that included partial second ray resection and extensive debridement of the dorsal and plantar soft tissue (Figure 1), the patient was subsequently admitted to the hospital for parenteral antibiotics, pain management, and glycemic control. NPWT therapy was initiated on postoperative day 1 and medicine consultation was obtained to ensure optimisation of the patient's other medical issues (10). On postoperative day 3, the patient was returned to the operating room for further debridement (Figure 2). At this time, all the remaining necrotic soft tissue and debris were removed and the plantar wound was closed utilising a foot-narrowing technique, which has been shown to be highly successful following partial central ray amputations in diabetic patients (11) (Figure 3). Postoperatively, NPWT was applied for several days to the dorsal foot wound, where a large soft tissue defect remained (Figure 4). Two days following the secondary debridement, it was decided to change the therapy of choice to Nanoflex powder dressing with the intent of providing moisture control (12,13), decreased dressing changes, and stimulation of wound healing. This nanoparticulate wound dressing was applied along the dorsum of the foot and was monitored daily.

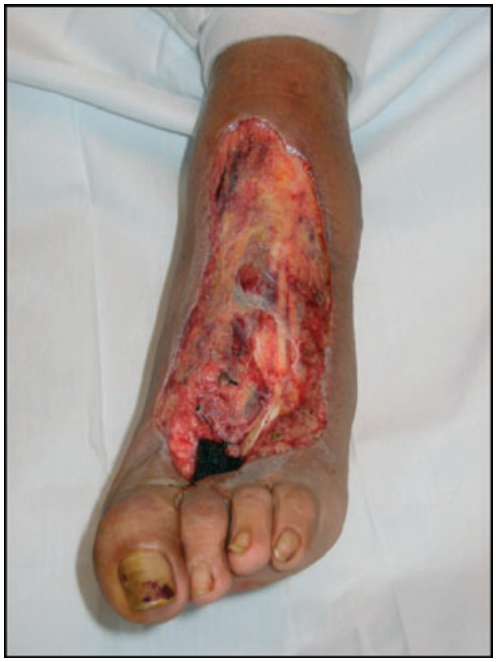

Figure 2. Dorsal foot wound after initial reconstruction and foot-narrowing procedure. The patient will eventually require a split-thickness skin graft.

DISCUSSION

Following serial debridement for necrotising fasciitis, the patient's wound management was transitioned from NPWT to Nanoflex powder dressing (Altrazeal from Uluru, Texas), which was applied to the dorsum of the left foot. This

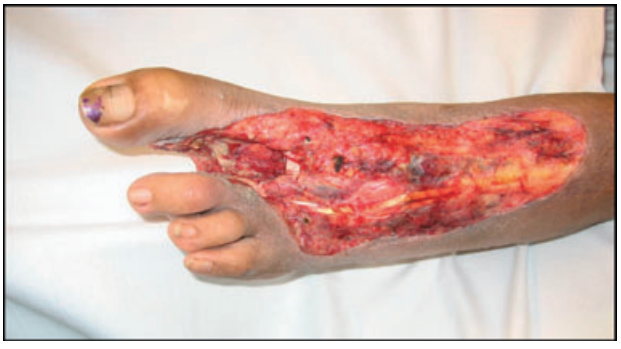

Figure 1. Necrotising fasciitis of the left foot following initial debridement.

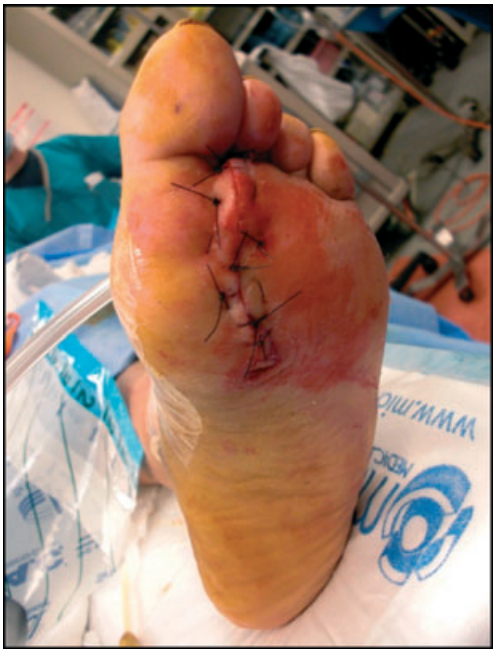

Figure 3. Plantar aspect of the left foot, following reconstruction.

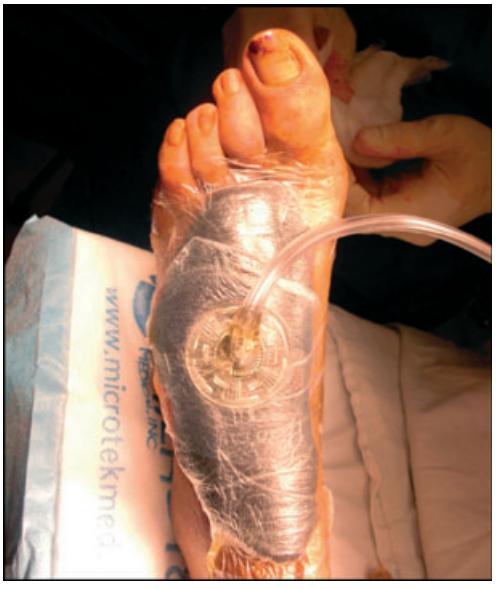

Figure 4. Application of negative pressure wound therapy (NPWT) to the dorsum of the left foot.

modality is the first product of its kind, derived from Nanoflex technology, a formulation technology that utilises nanoparticles which can be engineered to produce the optimal properties for a moist wound dressing. Nanoflex Powder is a sterile mixture of 85% poly-2-hydroxyethylmethacrylate (pHEMA) and 15% of poly-2-hydroxypropylmethacrylate (pHPMA), and is indicated for use in surgical wounds, exuding superficial acute wounds, such as donor graft sites and partial thickness burns, as well as in chronic, slow healing ulcerations (14). When applied to a moist wound bed, the sterile nanoparticle powder interacts with ionised fluid such as exudate, saline, or blood and converts to an aggregated, exudate-controlling wound dressing (Figure 5). Once in its aggregated form, the Nanoflex wound dressing conforms to the topography of the wound bed, filling dead spaces and sealing the wound margins. The porous architecture of the polymer created upon activation provides optimal oxygen and vapour transpiration, tensile strength, and flexibility, thus protecting the wound during healing. Capillary channels created upon nanoparticle aggregation serve to wick away exudate from the wound surface in the form of a moisture vapour at a transpiration rate of nearly 12 l/m^2 over 24 hours, while potentially promoting an optimal moist environment to allow for continued wound healing (14). Additionally, the nanoscopic pores which form this capillary network are too small to allow bacterial migration, thus, once in the aggregate state, the Nanoflex wound dressing serves to further reduce the risk of bacterial contamination (1).

To apply the Nanoflex wound dressing, it is necessary that the wound be first cleansed utilising a saline-moistened gauze (Figure 6). Once the wound is appropriately prepared, the Nanoflex powder is evenly poured over the entire surface of the wound (Figure 7), and then the wound is lightly sprayed with normal saline, which initiates the transformation from sterile powder to the aggregate dressing (Figure 8). Once hydration and aggregation have occurred, the dressing provides intimate contact at the wound-dressing interface, thus obviating the need for a primary wound dressing (Figure 9).

In the case presented, following serial debridement for necrotising fasciitis of the left lower extremity and subsequent delayed primary closure of the plantar foot wound, the patient was transitioned through a multitude of advanced wound healing modalities. NPWT was initially utilised in the postoperative setting to control drainage and to promote granulation tissue (7–9,15). The patient was then transitioned to a Nanoflex wound dressing on postoperative day 4. This dressing modality was selected because of the material properties

Key Points

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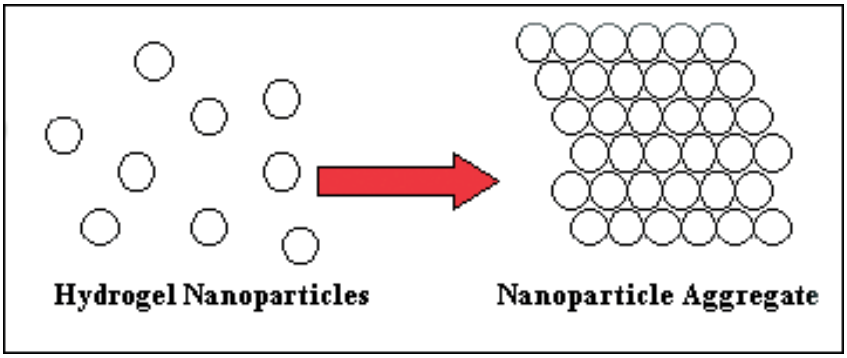

Figure 5. With addition of ionised fluid, nanoparticles transition to active aggregated, organised state and are stabilised by surfactant. Aggregate pore size provides capillary action to draw fluid away from the wound bed and prevent inward bacterial migration.

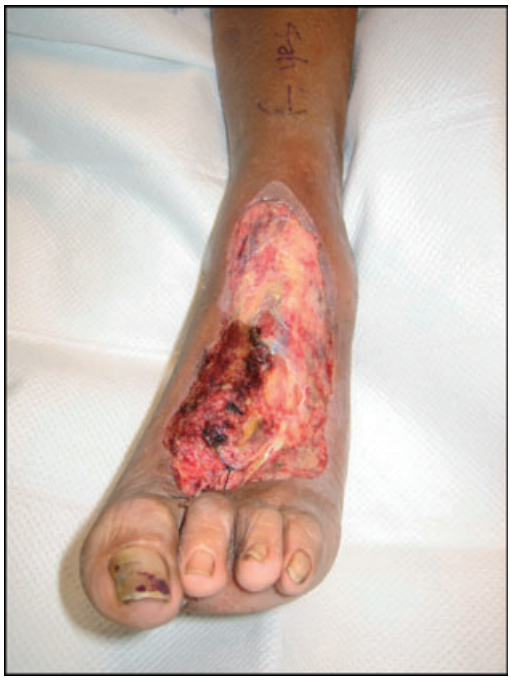

Figure 6. Two-day follow-up after negative pressure wound therapy (NPWT). Dorsal foot wound shows areas of desiccation.

Key Points

- the patient continued with the Nanoflex wound dressing upon discharge, and the wound was evaluated at weekly intervals when the dressing was changed
- at 3 weeks following original debridement, the patient was noted to have developed a healthy wound bed that was now ready for definitive wound closure
- the patient was returned to the operating room, and following wound bed preparation, a 0·016-inch split-thickness skin graft (STSG) was applied to the dorsum of the left foot
- the wound was noted to be 85% closed at 4 weeks following placement of STSG, and completely closed at 6 weeks following graft placement

of the Nanoflex technology and the ability to provide a moist wound healing environment without the drawbacks of more conventional wound dressings such as repeated application, pain with dressing changes and the need for secondary dressings (14). Additionally, the patient reported a decrease in pain associated with dressing changes transitioning between the NPWT and the use of Nanoflex powder dressing. We hypothesise that this reduction in pain is the result of a light cooling effect of the exudate control via vapour transpiration and subsequent reduction in inflammation as well as the intimate contact nature of the dressing.

The patient continued with the Nanoflex wound dressing upon discharge, and the wound was evaluated at weekly intervals when the dressing was changed. Interestingly, a reduction of previously noted dead space in the area of the resected second metatarsal head was observed at this time, and the nanoparticulate plug that had previously filled the space was noted to have been pushed free as granulation tissue infiltrated this location (Figure 10). This suggests that the Nanoflex wound dressing's nano-pore dimensions prevent cellular and matrix in-growth during wound bed maturation, thus eliminating increased patient discomfort with dressing changes. At 3 weeks following original debridement, the patient was noted to have developed a healthy wound bed that was now ready for definitive wound closure (Figure 11). The patient was returned to the operating room, and following wound bed preparation, a 0·016-inch split-thickness skin graft (STSG) was applied to the dorsum of the left foot (16) (Figure 12). The wound was noted to be 85% closed at 4 weeks following placement of STSG, and completely closed at 6 weeks following graft placement.

CONCLUSION

In the case presented, Nanoflex wound dressing was utilised to provide exudate control and to promote wound healing following radical debridement of the left lower extremity. This technology is a recently developed advanced wound healing modality that shows promise in the management of acute and chronic exudating wounds. Upon activation with

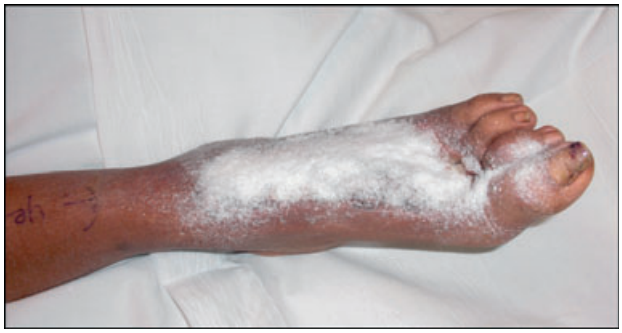

Figure 7. Application of Nanoflex hydrogel powder to the wound bed.

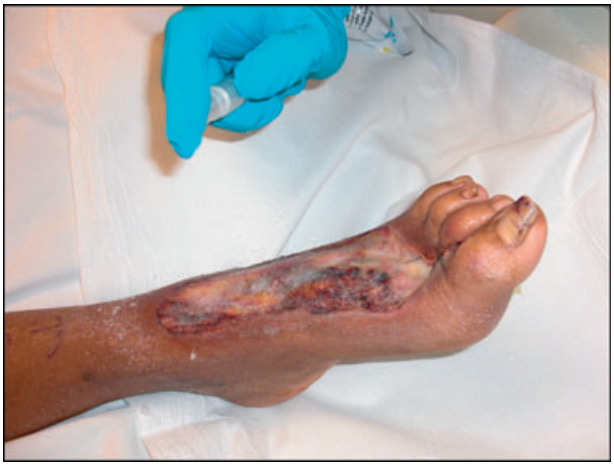

Figure 8. Ionic media activates nanoparticle aggregation, and the resultant aggregate hydrogel seals and conforms to the wound, providing moisture control and reducing bacterial contamination.

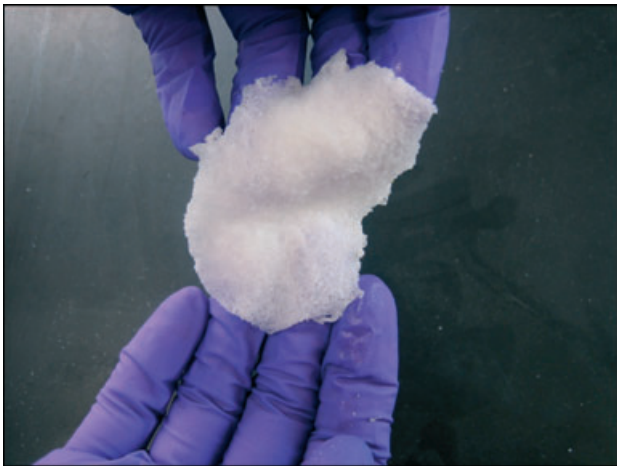

Figure 9. Nanoparticle aggregate dressing following application of ionic media (saline).

serum or exudate, the subsequent Nanoflex powder dressing provides moisture control for actively exudating wounds, in addition to reducing the risk of bacterial contamination. While this technology is in its early stages, there is significant potential for usage of the Nanoflex technology to serve as a delivery platform (14,17–20) for analgesics, antimicrobials, and pro-angiogenic compounds, and as such further research is necessary.

Key Points

- while this technology is in its early stages, there is significant potential for usage of the Nanoflex technology to serve as a delivery platform for analgesics, antimicrobials, and pro-angiogenic compounds, and as such further research is necessary

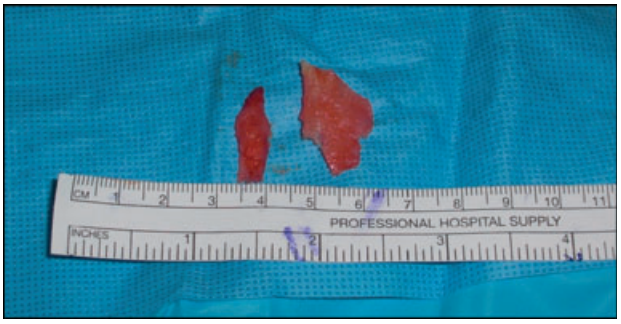

Figure 10. The nanoparticulate aggregate plug which had originally filled the dead space left following second metatarsal head resection was lifted up as granulation tissue formed in this location.

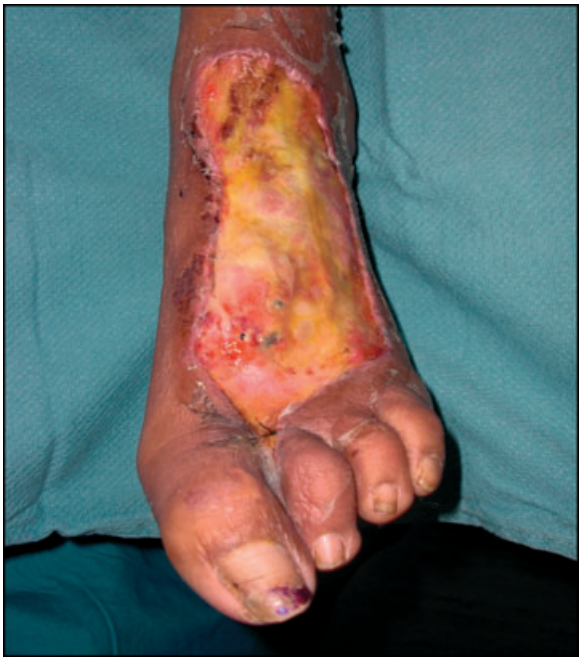

Figure 11. Dorsal foot wound approximately 2 weeks following revision surgery and application of nanoparticulate wound dressing. Granulation tissue formation and neo-epithelialisation is noted under nanoparticulate dressing layer.

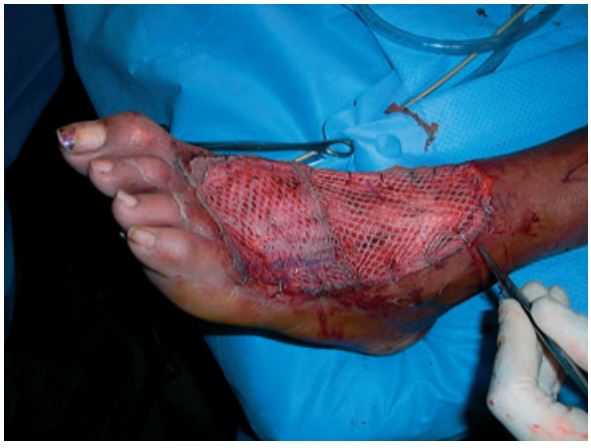

Figure 12. Placement of a 0·016-inch split-thickness skin graft to the dorsum of the left foot to provide definitive soft tissue closure.

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