CASE REPORT

Use of Chitosan-based Dressings for the Management of a Chronic Lower Limb Ulcer: A Case Report

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ABSTRACT

Introduction. Nonhealing ulcers are difficult to manage because they deviate from the normal wound healing process. The standard treatment with saline dressings is not efficient in treating patients with such wounds; advanced wound care dressings are needed. Chitosan-based advanced wound dressings are gaining popularity because of their unique characteristics, such as absorbency, conformability, and pain alleviation at the wound bed. A case of an ulcer that developed after cellulitis and healed with application of a chitosan-based dressing is presented. **Case Report.** An 81-year-old female with hypertension was admitted to the hospital with a high-grade fever, generalized weakness, anorexia, and right lower limb pain with redness. Venous insufficiency in the right lower limb in the form of early insufficiency at the right saphenofemoral and saphenopopliteal junctions along with right leg varicosities was evident on color Doppler ultrasound. A diagnosis of cellulitis was made; the patient was treated with antibiotics and discharged from the hospital. The cellulitis progressed, and an incision and drainage of the right leg was performed on the second admission. The patient was admitted twice more, and the wound was surgically debrided twice and antibiotics were administered. During this period, the patient was treated with saline dressing changes for almost 4 weeks. Because the wound was nonhealing and infected during the fourth hospital admission, chitosan-based dressings were used. Daily dressing changes for 10 days resulted in 100% granulation tissue. Later, the patient underwent skin grafting and was eventually discharged. **Conclusions.** The use of chitosan-based dressings resulted in progression to complete granulation, along with the management of exudate, pain, and *Pseudomonas* infection. The results of this case suggest patients with nonhealing ulcers may benefit from early use of advanced wound care dressings.

KEYWORDS

wound dressing, chitosan, chronic wounds, wound management, advanced wound care dressings

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Chronic ulcers are arrested in the inflammatory phase and generally do not proceed to the proliferative stage, resulting in delayed wound healing.[1] The serious complications of ulcers include septicemia, bone and joint infections, and gangrene. Management of the ulcer depends on ulcer severity and involves removal of dead tissue, administration of antibiotics in cases of clinical infection, and use of pain medications to relieve discomfort.[2] In patients with poor blood circulation or who are affected by blood disorders, treatment of ulcers can be prolonged in comparison with those who are not afflicted (normal population), and application of various methods may be necessary to improve circulation before ulcers can be treated.[3]

Cellulitis, which is a cause of leg ulceration, is an acute skin infection involving the dermis and subcutaneous tissues.[4] Patients with comorbid conditions such as diabetes, immunodeficiency, or impaired circulation are at increased risk of cellulitis. Moreover, in patients older than 65 years, cellulitis of the lower extremity is likely to lead to thrombophlebitis.[4] Cellulitis is usually managed with antibiotics; lack of treatment or delayed treatment places patients at risk of potentially serious problems such as sepsis, kidney damage, or the formation of leg ulcers.[5] The complications of cellulitis can be serious and can include extensive tissue damage, which may lead to gangrene. The infection can also spread to the blood, bones, lymphatic system, heart, or nervous system, resulting in amputation, shock, or death.

Treatment of ulcers depends on the type of ulcer. Arterial ulcers require primary treatment to restore blood circulation to the affected area in addition to the

Figure 1. Wound before treatment with advanced chitosan-based dressing.

administration of antibiotics to mitigate symptoms. Venous ulcers—the most common type of leg ulcer—can take months to heal fully. Management of these ulcers focuses on improving blood flow to the affected area; antibiotics are administered only in cases of clinical infections.[2] Chronic ulcers are typically heavily exudative, and the exudate contains inflammatory proteases and cytokines that are capable of attacking surrounding healthy skin if the exudate is not removed efficiently from the wound surface.[2]

A moist wound environment is essential in all phases of wound healing. It accelerates the reepithelialization process and collagen synthesis. It also facilitates the action of growth factors as well as keratinocyte and fibroblast proliferation, and it promotes angiogenesis.[2]

Necrotic tissue in chronic wounds can impair healing and impede keratinocyte migration over the wound bed. Debridement, or the removal of nonviable wound tissue, is essential to good wound bed preparation. Debridement can be performed using surgical, autolytic, enzymatic, biologic, or mechanical methods.[6] As the bacterial load increases to the point of critical colonization on wounds, healing becomes impaired as the result of local infection.[7] Infection may spread into surrounding tissues, resulting in deep infection, which may progress to systemic infection.[6] Addressing local wound infection using cleansing agents and topical antimicrobial agents can improve healing.

Various techniques are used in managing chronic wounds, such as wound dressings, negative pressure wound therapy, adjuvant wound therapies, and advanced dressing methods.[8] The 3 broadest categories of wound dressings include those that facilitate autolytic debridement, adjust moisture levels at the wound bed, and control the bacterial load.[9] The advanced wound care dressings are alginates, foams, hydrocolloids and hydrogels, iodine and silver-based preparations, and oxidized regenerated cellulose.[8]

Other advanced technologies currently in development involve the use of chitosan, which is a highly biocompatible and biodegradable polymer obtained from the shells of crustaceans. For over a decade, chitosan-based dressings have advanced the development of wound care dressings. They are particularly useful in wound management because of their nontoxic bacteriostatic and fungistatic properties.[10] These dressings have been successfully used to manage wounds of varying sizes and etiology, including chronic ulcers, diabetic foot ulcers, pressure ulcers, vascular ulcers, chronically infected wounds, traumatic wounds, postoperative wounds, and leg ulcers, as well as complex conditions such as epidermolysis bullosa.[11-14] One such dressing is MaxioCel (Axio Biosolutions Private Limited), which was developed using 100% chitosan. The dressing also has the advantage of transforming into a cohesive gel matrix on contact with the wound exudate.

This case report describes the effective use of a bioactive microfiber dressing following unsuccessful attempts to use conventional methods to achieve wound healing of a chronic right lower limb ulcer that developed after cellulitis. The patient described in the case provided informed consent to publish this report.

CASE REPORT

An 81-year-old female with hypertension who presented with a high-grade fever, generalized weakness, anorexia, and right lower limb pain with redness was admitted to the hospital. Age-related arteriosclerosis, predominantly in the distal arteries, and venous insufficiency in the right lower limb in the form of early insufficiency at the right saphenofemoral and saphenopopliteal junctions, along with right leg varicosities, were evident on color Doppler ultrasound. Ultrasonography of the abdomen and pelvis revealed no significant abnormality. Cellulitis of the right leg was diagnosed. The patient was administered intravenous fluids, antibiotics, linezolid injection, cefoperazone, sulbactam injection, the anti-inflammatory agents trypsin and chymotrypsin, paracetamol, and acetylsalicylic acid. Other supportive therapies included atenolol for hypertension, pantoprazole for stomach acidity, lactulose for constipation, racecadotril and probiotics for acute diarrhea, donepezil for dementia, and escitalopram oxalate and desvenlafaxine for depression.

The patient was admitted for the second time 4 days later with cellulitis and an abscess of the right leg. During this admission, the patient underwent incision and drainage under general anesthesia to remove the abscess at the site of cellulitis. The patient tolerated the procedure well and was administered intravenous fluids, antibiotics, linezolid injection, and cefoperazone and sulbactam injection. After 18 days, the patient was admitted for the third time, this time with an infected ulcer. The ulcer was surgically debrided and managed with injections of colistimethate sodium, amoxicillin and potassium clavulanate, and tramadol, as well as oral paracetamol.

One day after hospital discharge (third admission), the patient was admitted a fourth time with a nonhealing, infected wound. Another debridement of the wound was performed. The ulcer was infected, with a complex presentation. The patient underwent a thorough evaluation, and acute kidney injury and a nonhealing ulcer were diagnosed. The patient received daily saline dressing changes for 4 weeks. Because wound healing did not improve with the use of standard saline dressings, the authors used chitosan-based dressings to manage the nonhealing ulcer. Swab culture showed the presence of *Pseudomonas aeruginosa*, which was sensitive only to colistimethate sodium. Based on the culture report, aztreonam was added to treat *P aeruginosa*. The chitosan-based dressings were started on the 15th day of the 4th admission. At the time of initial chitosan-based dressing application, the ulcer had been present for 4 weeks and measured 15 cm × 5 cm × 2 cm (length, width, and depth, respectively). The wound appeared to have moderate exudate levels, with 60% slough and 40% granulating tissues, and the patient reported severe pain at the wound site (**Figure 1**).

After 10 days of daily treatment with the chitosan-based dressings (**Figure 2**), the wound showed 100% granulating tissue. Pain and exudate levels were reduced, and absence of pseudomonal growth was confirmed by the swab culture. The authors believe the ease of dressing application and removal was excellent. The patient reported the dressings were comfortable to wear. Because of the improvement in the wound condition, the patient underwent skin grafting and was successfully discharged from the hospital after a total of 58 days (during the last admission).

Figure 2. Appearance of the wound after treatment with advanced chitosan-based dressing.

DISCUSSION

Chronic lower extremity ulcers are common and challenging to heal. Wound healing is a complex process involving the spatial and temporal synchronization of various cell types with distinct roles in the phases of hemostasis, inflammation, growth, reepithelialization, and remodeling.[15] Chronic ulcers do not proceed through the normal phases of wound healing in an orderly and timely manner. Despite differences in etiology at the molecular level, various types of chronic wounds share certain common features, including excessive levels of proinflammatory cytokines and proteases, as well as persistent infection and a deficiency of stem cells that also are often dysfunctional.[1]

A moist environment is highly beneficial to wound healing because it increases the rate of epithelization 2-fold. Modern dressings aim to expedite healing, achieve a moist environment, remove excess exudates, provide ongoing protection from (or treat) bacterial contamination, and reduce odor and pain.[16] Moist gauze dressings are somewhat efficacious. However, these dressings also have a wide range of limitations such as maceration, lint and/or fiber residue remaining in the wound after removal, removal of healthy tissue at dressing changes, and the requirement of repeated moistening to maintain proper wound moisture balance.[13]

To manage chronic ulcers, the ideal wound dressing should maintain optimum moisture level in the wound bed. The dressing should be nontoxic, act as a bacterial barrier, and be hemostatic for minor bleeding and promote wound healing. Additionally, it should serve to manage pain and scar formation at the site and should be easily removable. The basic principles of wound care involve thorough assessment along with medical and nutritional optimization, debridement, offloading, and management of ischemia and infection. Moreover, appropriate preparation of the wound bed is important in providing a proper environment in which tissue repair can occur.[1] A suitable wound bed that is well vascularized with minimal bacterial burden and minimal exudate level is crucial. Wound characteristics such as edema and odor should also be addressed.

One such wound dressing is chitosan based. Chitosan is polycationic at a pH less than 6, and it readily interacts with negatively charged molecules, such as proteins, anionic polysaccharides, fatty acids, bile acids, and phospholipids. Chitosan-based wound dressings have been successfully used in the management of chronic wounds and ulcers and have been shown to be safe and effective. In a randomized controlled study evaluating the use of these dressings to manage clinically diagnosed unhealed or nonhealing chronic wounds (pressure ulcer, venous leg ulcer, diabetic foot ulcer, and minor infective wound), chitosan-based dressings were associated with a marked reduction in wound size compared with petroleum gauze.[11] The dressings were also efficacious in exudate management and pain management and had no side effects. Their study demonstrated that chitosan-based dressings promoted faster wound healing and were easy to remove. Use of the chitosan-based dressing also resulted in an improved healing rate of infected wounds compared with petroleum gauze.[11] In a randomized controlled trial, Kordestani et al[12] reported that use of chitosan-based dressings resulted

in a significantly increased rate of wound healing compared with traditional dressings in patients with diabetic foot ulcers and venous ulcers (P <.001). Unlike in the control group, none of the wounds in the treatment group became infected; thus, antibiotics were not required in patients treated with chitosan-based dressings. Clinical study results support the use of chitosan-based gelling fiber dressings on nonhealing, chronic wounds with various complex etiologies. Furthermore, studies have shown application and removal of the dressings is easy and effective hemostatic outcomes can be achieved.[13,17,18] It is noteworthy that the chitosan-based dressings have been shown to benefit patients with underlying health conditions, such as diabetes, hypertension, deep vein thrombosis, peripheral vascular disease, neuropathy, coronary heart disease, and ischemic heart disease.[13,17,18]

Although the current case had multiple comorbidities in addition to the nonhealing ulcer, the chitosan-based dressing showed remarkable results in managing pain, exudates, and *Pseudomonas* infection. The dressings were conformable and exhibited high integrity; they did not disintegrate during removal. The use of chitosan-based dressings resulted in improved wound healing compared with the saline dressings used initially. Complete granulation was achieved after 10 days of treatment with the chitosan-based dressings, whereas saline dressings were used for 4 weeks without any improvement in granulation tissue formation.

LIMITATIONS

The only limitation is that the patient required antibiotics to manage the cellulitis. As a result, it was not possible to evaluate the antibacterial activity of the dressings.

CONCLUSIONS

The current case details the effective use of chitosan-based dressings on a complex wound after unsuccessful attempts to achieve healing using conventional methods. The chitosan-based dressings were nonadherent, demonstrated antimicrobial properties, and maintained a moist wound healing environment that is beneficial for wound healing. In this case, use of the chitosan-based dressings resulted in complete granulation tissue formation within 10 days of application; whereas prior to receiving that dressing, the wound had been unsuccessfully managed with saline dressings for 4 weeks. This case showed early use of chitosan-based dressings may result in improved chronic wound healing outcomes.

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