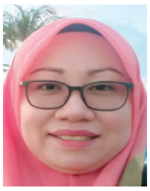
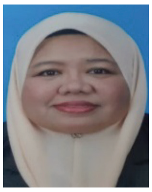
Managing a crush injury of the foot and diabetic heel ulcer with osteomyelitis with chitosan-based dressings

In this article, the authors present two interesting case studies. The first case was a patient with a crush injury of the foot with multiple fractures and extensor tendons cut, while the second case was a patient with a chronic, non-healing diabetic heel ulcer, which was complicated by osteomyelitis. In both cases, the authors wanted to study the effects of chitosan on the wound healing process. Both cases demonstrated positive patient outcomes after chitosan-based dressings had been used to treat the patients' wounds.

Authors:
Joshua Jeevan, Wan Saleh Wan Safarizan, Abdul Ghani Norfarahwati

Joshua Jeevan *is Medical Officer, Wound Care Unit, Seri Manjung Hospital, Perak, Malaysia;* ***Wan Saleh Wan Safarizan*** *is Registered Nurse, Wound Care Unit, Seri Manjung Hospital, Perak, Malaysia;* ***Abdul Ghani Norfarahwati*** *is Registered Nurse, Wound Care Unit, Seri Manjung Hospital, Perak, Malaysia*

Chitosan and its derivatives are obtained from shells of shrimp and other crustaceans. Chitosan has numerous commercial and biomedical uses which include haemostatic and excellent wound healing properties. Chitosan comprises of copolymers of glucosamine and N-acetyl-glucosamine units linked by β-1,4-glycosidic linkages (Jia et al, 2011). Chitosan and its derivatives accelerate wound healing by enhancing the functions of inflammatory cells such as polymorphonuclear leukocytes (PMN), macrophages, fibroblasts or osteolasts (Dai et al, 2011). Chitosan has been shown to promote wound healing by inducing bone formation and also with its inhibitory effects on microorganisms like *Candida*, *Klebsiella*, *Pseudomonas*, *Staphylococci*, and *Streptococci* (Jayakumar et al, 2011).

In this article, we present two interesting cases of one patient with a traumatic injury and another patient with a diabetic foot ulcer. The first case was a patient with a crush injury over the foot with multiple fractures and extensor tendons cut while the second case was a patient with a non-healing, 5-month-old diabetic heel ulcer with osteomyelitis. Both were successfully treated using chitosan-based dressings.

Crush injuries of the foot can present with complicated and difficult-to-manage deformities, fractures and the wound itself. Understanding the true mechanism of injury and providing treatment is crucial for favourable outcomes. These are serious injuries with high rates of amputation especially on the elderly group with multiple comorbidities. Soft tissue coverage of wounds is vital to limb salvage and to decrease infection rates (Vora et al, 2002).

Malaysia has the highest rate of diabetes in the Asia Pacific and almost one in five Malaysians adults has diabetes mellitus (Ministry of Health Malaysia, 2015). It is estimated that 24.4% of the total healthcare expenditure among the diabetic population is related to foot complications, which include diabetic foot ulcers and lower limb amputations (Sargen et al, 2013).

This study was conducted to evaluate the effectiveness of chitosan-based dressing in wound bed preparation of a crushed foot injury after wound debridement for early wound closure and healing a chronic, 5-month-old diabetic heel ulcer with osteomyelitis of the calcaneum.

First case history

In this case study, we present a 20-year-old male with a non-contributory medical history, who was involved in a motor vehicle accident and sustained a crush injury over the dorsum of the left foot *[Figure 1a]*. He claimed no other injuries or loss of consciousness. The wound was dirty and heavily contaminated with sandy materials. He had sustained multiple fractures over the metatarsal and tarsal bones *[Figure 1b]*. His toes were pink and warm to

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Figure 1a. *Day 1: Crush injury over the dorsum of left foot with loss of soft tissue coverage*

Figure 1b. *Day 1: X-ray revealed multiple fractures from the metatarsal and tarsal bones*

Figure 1c. *Day 7: Wound bed with moderate exudate with exposed extensor tendons*

Figure 1d. *Day 16: Wound bed with 40% of granulation tissue, minimal exudate with epithelializing edges*

Figure 1e. *Day 28: Wound bed with 65% of granulation tissue, minimal exudate with epithelializing edges*

Figure 1f. *Day 36: The wound after split skin grafting and K-wire removal*

touch. Peripheral capillary oxygen saturation ($Sp0_2$) of more than 95% was detected for all the toes. Despite the significant trauma, the patient's dorsalis pedis and posterior tibial pulses remained palpable. Upon arrival at the Emergency Department, blood loss was minimal with no pulsatile bleeding. The wound was meticulously debrided, fractures stabilized with wires, exploration and extensor tendon repair done. The patient was referred to a wound care unit on Day 7 after completion of intravenous antibiotics. Initial assessment revealed a wound with moderate exudate measuring 9 cm x 16 cm x 1 cm *[Figure 1c]*. The wound was composed of viable exposed extensor tendons and slough with a moderate amount of granulation tissue. The periwound dry with no signs of local infection.

Methods

The wound progression and pain were assessed using charts provided by the Malaysian Ministry of Health (MOH). All dressing procedures were carried out based on the MOH Standard Operating Procedures with universal precautions. The wound was cleansed and soaked with silver-based solution, then the chitosan-based gel was applied onto the wound bed, packed with conventional dressings and covered with a bandage. Povidone pin tract dressing was done and all the toe-web spaces were covered with a piece of gauze to avoid maceration and fungal infections. This protocol was repeated daily for the first seven days and then was converted to an every-other-day-regimen. The patient was advised to stop smoking and was referred to quit smoking clinic. He was strictly advised to ambulate via crutches and to carry out active range of motion exercise for the knee joint as a below-knee backslab was applied to support the fractures. Moreover, the dietitian was consulted for a nutritional supplement to enhance wound healing.

Results

Wound healing was observed from a moderate exudative wound *[Figure 1c]* to a moist wound

Figure 2a. *Day 1: The wound over the right heel measuring 6 cm x 3 cm x 4 cm*

Figure 2b. *Day 1: 80% of slough and fat tissue with no pus, 20% pale granulation tissue*

Figure 2c. *Day 4: 60% of slough and fat tissue, 40% granulation tissue*

Figure 2d. *Day 8: 25% of slough and fat tissue, 75% granulation tissue*

Figure 2e. *Day 17: Fully granulated*

Figure 2f. *Day 29: Wound is contracting*

Figure 2g. *Day 40: Wound is contracting*

Figure 2h. *Day 55: Fully re-epithelialized*

bed with rapid slough reduction from Day 10 to Day 28 *[Figure 1d and 1e]*. The wound was made up of almost 65% granulation tissue, 20% of epithelized tissues with partial bone and tendons exposed but by Day 36 after split skin grafting and K-wire removal there was significant improvement *[Figure 1f]*. The patient required oral opioid analgesia thrice per day initially and intramuscular opioid analgesia during the first 5 days before dressing. The pain score gradually reduced from Day 16 onwards. The patient underwent split skin grafting after a healthy granulating wound bed with a negative infective status on the Culture and Sensitivity (C&S) report. The grafting was a successful procedure with good skin uptake and the patient was referred to the physiotherapy team for a range of motion exercise of the ankle and toes on Day 60.

Second case history

A 72-year-old female patient with diabetes mellitus (and on insulin therapy for 21 years), hypertension and ischemic heart disease, presented with an ulcer she had for over 5 months. She developed a necrotic patch after a trivial injury on her right heel which was excised during the third month. The wound failed to respond to conventional dressings. Wound assessment revealed an ulcer measuring 6 cm x 3 cm x 4 cm *[Figure 2a and 2b]* composed of 80% slough and fat tissue, with the remainder being pale granulation tissue. The macerated periwound showed signs of local inflammation. The distal pulses were well palpable and the ankle brachial pressure index (ABPI) charted 0.97. An X-ray revealed periosteal reaction over the calcaneal bone. The patient was suggested for maggot debridement therapy but was not pursued due to helminthophobia (the fear of being infested with worms). She was informed about the possibility of below-knee amputation if the wound deteriorated with worsening signs on X-ray finding.

Methods

The wound and pain were monitored by charts provided by the MOH. All dressing procedures were carried out based on MOH

Standard Operating Procedures with sterile dressing methods. The wound was cleansed and soaked with silver solution, chitosan-based hydrogel was applied onto the wound bed, packed with conventional dressings and bandaged. This protocol was repeated daily for the first eight days and then was converted to an every-other-day-regimen. Frequent sharp and mechanical debridement were carried out to enhance wound healing. In addition, the patient was referred to a nutritionist for dietary advice and food supplements which can aid wound healing. She was advised to do calf-strengthening exercises with a strict glycaemic control as this is critical for wound healing. The patient was recommended to ambulate via crutches and to offload the heel while sleeping by placing a pillow under the calf region.

Results

The initiation of using chitosan-based dressings with tri-weekly follow up, resulted in complete re-epithelization *[Figure 2h]* after 7 weeks of treatment. A moist wound bed observed from Day 4 *[Figure 2c]* with gradual slough tissue reduction from Day 8 *[Figure 2d]* until complete granulation on Day 27 *[Figure 2e]*. The wound started contracting *[Figure 2f and 2g]*, with local inflammation and pain score markedly reduced from Day 8 *[Figure 2d]*. Ankle range of motion was full upon completion of treatment.

Discussion

The prominent features of chitosan could be pivotal in wound healing in these two patients with partly exposed bone. Chitosan-based hydrogels have been demonstrated to promote wound healing at different wound healing stages, and also can alleviate the factors against wound healing (such as excessive inflammatory and chronic wound infection) (Liu et al, 2018). Chitosan therapy was well-founded in these patients and the application of chitosan-based dressings further enhanced wound healing, which may due to their ability to enhance autolytic debridement and to hydrate the wound as a whole.

Conclusion

Using chitosan-based dressings was effective in accelerating the wound healing in these two patients — one who had suffered a traumatic wound and the other from a chronic heal ulcer. However, a thorough wound assessment is vital before the application of this dressing. Larger clinical trials are needed to establish the efficacy of chitosan-based dressings in promoting wound healing. WAS

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