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INTERNATIONAL JOURNAL OF
Veterinary Science and Research
OPEN ACCESS JOURNAL

ISSN: 2640-7604 DOI: https://dx.doi.org/10.17352/ijvsr

Short Communication

Innovative approaches in equine wound management: Addressing challenges and their remedies

Ayat Fatima* Sayyed Aun Muhammad and Abdul Mateen

Department of Veterinary Clinical Surgery and Medicine, UVAS, Subcampus, Jhang, Pakistan

Received: 12 April, 2024
Accepted: 23 April, 2024
Published: 24 April, 2024

***Corresponding author:** Ayat Fatima, Department of Veterinary Clinical Surgery and Medicine, UVAS, Subcampus, Jhang, Pakistan,
E-mail: ayatfatimavet@gmail.com

Keywords: Equine wounds; Biofilm; Exuberant; Soundness; Resistance; Innovative

Abstract

Horses are highly susceptible to musculoskeletal wounds due to the demands of their work, whether in transportation or as athletes. These wounds significantly impact the overall performance of horses, emphasizing the importance of effective wound management for optimal functionality. Among equine wounds, distal limb injuries are prevalent, accounting for over 60% of all cases. However, managing wounds in these extremities poses considerable challenges, as poor healing often leads to the formation of exuberant granulation tissue. In equine practice, biofilms are frequently observed in wounds with delayed healing, and there is an alarming rise in the incidence of multi-drug-resistant microbial strains. Consequently, there is an urgent need to implement advanced strategies in wound care management to address these clinical scenarios effectively. Maintaining the soundness of the musculoskeletal system is crucial for horses, particularly those destined for athletic careers. Thus, ongoing trials in equine clinical practice aim to explore innovative approaches for achieving effective wound healing. This article highlights the importance of innovative strategies in equine wound management and emphasizes the need to address challenges such as exuberant granulation tissue formation, biofilm presence, and multi-drug-resistant microbes. By implementing these innovative approaches, equine clinicians can enhance wound healing outcomes and ensure the optimal health and performance of horses.

Introduction

Wounds in horses can have a significant impact on their overall performance and well-being. The nature of wound healing in equine is different from that in other animals, as shown by the differences in the capacity and efficiency of the leukocytes to produce inflammatory mediators. That results in either delay or defects in wound healing and repair, which have adverse effects on the musculoskeletal system. Another issue is the formation of biofilm in chronic nonhealing wounds thus emphasizing the exploring of adjunctive approaches. Good wound management is crucial for maintaining the normal functionality of their musculoskeletal system. There are discussing innovative approaches that could be used as adjunctive therapy to routine wound management for proper healing and restoration of normal functionality of the musculoskeletal system.

Biodebridement

The overall objective of debridement is to remove the devitalized tissue as much as possible, followed by the application of topical therapy and systemic therapy if necessary. There are several methods of debridement, such as hydrogen peroxide or Epsom salt, but the development of infections involving biofilms has important implications for wound healing as they are more resistant to typical topical antimicrobial therapy. Bacterial biofilms are structured groups of bacteria that adhere to a surface and are surrounded by a three-dimensional extracellular matrix [1]. Factors that increase the likelihood of wound infection and biofilm formation consist of the existence of foreign objects, sequestra, and surgical implants, diminished blood flow to the affected area, inadequate response to antimicrobials, and the immune condition of the patient (including age, sepsis, malnutrition or obesity, antibody deficiencies, chronic stress, corticosteroid

Citation: Fatima A, Muhammad SA, Mateen A (2024) Innovative approaches in equine wound management: Addressing challenges and their remedies. Int J Vet Sci Res 10(2): 016-020. DOI: https://dx.doi.org/10.17352/ijvsr.000145

use, or underlying medical conditions). Biofilm-based chronic non-healing wounds need repeated debridement with effective topical therapy [2-4].

Biodebridement, also called maggot therapy, has been practiced in human wound management, but in the literature, there is little published data regarding the use of this therapy in veterinary practice. It has been proven that biodebridement using L sericata larvae not only provides rapid debridement and angiogenesis but also that their secretions have antibacterial effects [5]. In the past, this therapy had been used effectively to treat wounds in human patients, but with the development of antibiotics, its use decreased. Keeping in view the current situation of antimicrobial resistance, there is a need for the use of maggot therapy for the debridement of chronic nonhealing wounds. Just like in human practice, this therapy could be effective in equine practice as well, especially when dealing with chronic nonhealing ulcerated wounds. Maggots play a crucial role in the debridement of chronic wounds and healthy granulation tissue formation. Secretions as well as excretions have an inhibitory role in bacterial as well as fungus growth [6]. Such unique features of maggots highlighted their role in nonhealing wounds that don't respond to routine debridement procedures. This therapy will be effective in wounds of lower limb extremities, like wounds below the hocks and carpus in horses, which are more prone to biofilm and exuberant granulation tissue formation. Chronic laminitis cases of sepsis/necrosis within the hoof benefit from this procedure due to the noninvasive, continuous debridement and healing properties provided by the larvae. Also, Poorly healing wounds like fistulous withers will surely respond to this therapy [7].

Honey

Honey has anti-oxidant, anti-bacterial, and anti-inflammatory properties [8]. Cutaneous wounds like wounds induced by trauma, surgery, and burns lead to non-functionality of the affected area. Many methods have been developed, like topical antimicrobial therapy after debridement, but this is not effective in cases of infection with multi-drug-resistant pathogens. Alternative approaches are sought out to deal with such wounds. Honey, a natural substance, comprises a wide variety of active compounds, including flavonoids, organic acids, enzymes, and vitamins, that may act to improve the wound healing process. It is effective for the treatment of a broad range of wound types, including burns, scratches, skin abscesses, malignancies, leprosy, fistulas, leg ulcers, septic and surgical wounds, etc. Literature has shown that honey is very effective when applied topically in the form of a layer over contaminated wounds after debridement because it has a wide therapeutic scope in wound healing and repair. It has a lot of benefits, like broad-spectrum antimicrobial activity against bacteria and fungi, antioxidant properties, and being an immune modulator. Thus, medical-grade sterilized honey is effective in wound management. Honey can be combined with zinc oxide or with silver sulfadiazine for the proper development of healthy granulation tissue while minimizing complications [9].

Platelet-rich plasma

Cutaneous distal limb wounds in equine have a poor prognosis and prolonged healing due to increased motion, lack of soft tissue support, and poor blood supply. They are very challenging for a veterinarian as they are typically healed by second intention, which makes them more vulnerable to complications as well as life-threatening for the animal. Platelets have a basic role in hemostasis, and they release different cytokines for the recruitment of neutrophils and growth factors that help in tissue repair and healing. Published literature regarding its use in wound management has shown that it is a very beneficial therapy in the healing of large wounds without any formation of exuberant granulation tissue. Platelet-rich plasma in gel form showed the best result on wound healing of the distal limb of horses in both clinical and histopathological evaluations [10]. It is a safe and inexpensive topical therapy for wound healing in equine practice. Moreover, it could be used as an additional therapy along with skin grafting because of its numerous benefits, like the maintenance of a better moist environment required for healing, slowing the degradation and preservation of skin grafts, and providing growth factors for healing. It is a safe, economical, and very efficient therapy for the treatment of non-healing wounds [11,12].

Topical negative-pressure therapy

This therapy aims to enhance angiogenesis and fibroplasia and reduce edema and infection. In this therapy, sub-atmospheric pressure is applied to a wound to reduce inflammatory exudate as well as promote granulation tissue [13]. It is effective in cases of full-thickness burns, avulsion wounds, and chronic nonhealing wounds. This therapy reduces seroma formation and wound dehiscence. Benefits include the elimination of liquid and debris, reduction of the bacterial load, and promotion of angiogenesis, which results in the production of granulation tissue and quicker wound closure. Literature has

Figure 1: NPWT application in a horse with parotid gland duct rupture secondary to sialolithiasis.
The horse presented extensive skin necrosis and exudate drainage (a). Wound after debridement (b),
the parotid gland was exposed and NWPT was applied (c,e,f). Picture of the sialoliths obstructing the
parotid gland, after removal using a transbuccal approach (d). An healthy granulation tissue started
forming after 5 days (g,i). Picture of the fluid collected within the canister (h) (Cantatore, 2023)

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shown that it could be used in conjunction with skin grafts for the treatment of large traumatic, non-healing wounds.

Regenerative medicine

The creation of new tissues to replace or restore native tissues that are absent, lost, or damaged as a result of aging, disease, injury, or congenital defect is known as regenerative medicine in its broadest sense. Regenerative medicine in veterinary care encompasses a range of treatments that serve as an alternative to skin grafting, aiming to repair damaged tissues or organs in animals. For example, in cases like tendonitis in horses, where scar tissue may form, regenerative medicine seeks to introduce living cells or tissues to stimulate regeneration and enhance healing. This field, known as veterinary regenerative medicine, is actively exploring cell and tissue therapies for animals, referred to as animal cells, tissues, and cell- and tissue-based products. These cells and tissue-based products which include stem cells and blood tissues, are designed to be implanted, transplanted, or transferred from a donor to an animal recipient, potentially even across different species. Ongoing research in this area is continually advancing these innovative therapies, holding promise for the development of safe and effective treatments for various animal diseases and conditions [14].

Stem cell therapy

Cell potency refers to a cell's ability to divide and differentiate into various cell types. Totipotent cells can give rise to all cell types and are found in the zygote and its subsequent blastomeres in mammals. Pluripotent cells, on the other hand, can differentiate into almost all cell types, including embryonic stem cells and induced pluripotent stem cells, which can differentiate into cells from any of the three germ layers. Multipotent cells are progenitor cells capable of differentiating into a closely related group of cells. For example, multipotent blood stem cells, known as hematopoietic cells, can differentiate into multiple types of blood cells. The therapeutic potential of stem cells lies in their ability to produce growth factors, attract native reparative cells, and supply healthy, differentiated cells to damaged tissues. Even stem cells with limited potency, such as mesenchymal stem cells primarily associated with differentiation into osteoblasts, chondrocytes, and adipocytes, have been shown to positively impact the process of cutaneous wound healing. Stem cell therapies in equine veterinary medicine have primarily been used to address musculoskeletal disorders [14] Stem cells are emerging as a progressively encouraging therapeutic option in veterinary clinical practice.

Nanoparticles

Nanoparticles play an important role in wound healing through prompt granulation tissue development, reducing scar width, and a higher epithelialization rate. Nanomaterials can accelerate wound healing by promoting cell migration, proliferation, and differentiation, as well as modulating the inflammatory response and promoting angiogenesis. Nanoparticles can be used in wound healing applications for animals. They can be incorporated into dressings or coatings

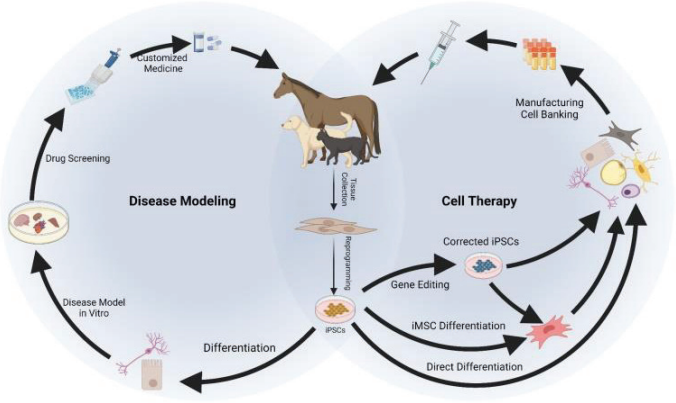

Figure 2: Applications of induced pluripotent stem cells (iPSCs) in companion animals for disease modeling and therapy.
(Barrachina, 2023)

to promote tissue regeneration, prevent infection, and enhance wound closure. Nanoparticles can also be loaded with growth factors or antimicrobial agents, further aiding in the healing process. For example: Silver nanoparticles [15] are used as additives in the fabric of the equine's bandage as a part of wound dressing to improve the mechanical potential and accelerate the healing rate. They reduced wound inflammation and biofilm complications, along with improved healing activity. Similarly, gold nanoparticles [15] have been proven to provide beneficial effects for racehorses by healing joint and tendon injuries by improving the drug delivery system [16].

Self-inflating tissue expanders

The inherent property of skin to expand, as seen in weight gain, has been utilized in human medicine to assist in reconstructive surgery for wound healing. Tissue expansion has now become a widely accepted method in human reconstructive surgery with various uses such as repairing cleft palates and removing burned skin, and other issues. The use of skin expansion devices in clinical veterinary practice was first reported in 1989 by clinicians using a silicone expander that was gradually inflated with saline solution [17].

The shape of the wound is important to consider in treatment. Small wounds can often be closed by loosening the surrounding skin to reduce tension, closure of larger wounds like rectangular wounds usually requires skin manipulation to create a flap that can cover the wound. Sometimes, H plasty may be necessary to cover a circular wound. Reconstructive flaps offer advantages such as maintaining blood supply and matching the appearance and texture of the site. However, successful use of skin flaps depends on having enough skin available to ensure both the donor and recipient sites can be closed without excessive tension. Self inflating tissue expansion could be an alternative approach for managing wounds where enough skin is not available for making reconstructive flaps. Skin expansion is a technique that involves two surgical procedures: the placement of skin expanders and subsequent reconstruction using the expanded skin. Flaps created from expanded skin have a higher likelihood of survival compared to those made from acutely mobilized skin, likely due to the

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improved blood supply in the expanded skin. Research in pigs has shown that skin flaps from expansion have a higher number and better quality of blood vessels [18]. Despite these benefits, the use of tissue expanders in veterinary surgery, particularly in equine procedures, is not widely practiced, and there is limited information available on the devices used and their associated outcomes.

Discussion

Implementing these innovative approaches in equine wound management is crucial because musculoskeletal wounds can have a significant impact on the overall performance of horses. By focusing on effective wound management, veterinarians and horse owners can ensure optimal functionality and well-being for their equine partners. It is important to delve into specific innovative approaches that have shown promise in equine wound management. For example, advanced wound dressings like hydrogels or bioactive dressings provide a conducive environment for wound healing and can help prevent the formation of exuberant granulation tissue. Regenerative medicine techniques such as platelet-rich plasma (PRP) or stem cell therapy have also demonstrated the potential to enhance wound healing by promoting tissue regeneration. Addressing biofilms and multi-drug-resistant microbes, It is crucial to explore innovative strategies to effectively manage these issues. For instance, the use of antimicrobial agents or biofilm-disrupting agents can help address biofilm presence and combat multi-drug-resistant microbes. Research in this area may involve the development of novel antimicrobial treatments or the exploration of alternative therapies. By improving wound healing outcomes, these strategies can have a positive impact on the overall health and performance of horses. Previous research done in equine wound healing using Regenerative medicine, Negative pressure therapy, and nanoparticles has proved that they are promising approaches for effective healing. Limited Research data is available on approaches like tissue expansion. That's why it is important to acknowledge that further research and clinical trials are needed to validate the efficacy and safety of these innovative approaches.

Conclusion

Wound management depends on the type of wound, its severity, and its anatomic location. Proper debridement and antiseptic dressings are the key principles that reduce wound inflammation, biofilm complications, and the count of odor-causing bacteria, along with improved healing activity. Making an immediate treatment plan is crucial when dealing with a wounded horse, but when making important decisions, it's also important to think about the long-term objectives and the strategy to reach them. Whatever approach is followed, minimizing wound complications is one of the key objectives. That's why using innovative approaches as discussed, like platelet-rich plasma, etc., in conjunction with routine therapies could be very beneficial.

These advanced therapies have shown promising results in not only accelerating healing but also improving the overall quality of healing, leading to better long-term outcomes for the horse's well-being. Therefore, incorporating these cutting-edge techniques into the treatment plan can greatly contribute to achieving optimal healing and restoring the horse's normal functionality in the long run.

Acknowledgement

I thank the Sayyed Aun Muhammad DVM, M.Sc. Hons. Clinical Medicine and Surgery (UAF)Assistant Professor/ Associate Senior Tutor and Mr. Abdul Mateen DVM, M.Phil Clinical Medicine and Surgery (UVAS) Lecturer UVAS,subcampus, Jhang for providing material and guidance.

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