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Efficacy of Honey-Based Wound Dressing Versus Hydrogel-Based Wound Dressing in Wound Healing Process: A Literature Review

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ABSTRACT

Introduction: Wound dressing is a fundamental aspect of modern healthcare, encompassing a diverse range of materials and techniques aimed at optimizing the healing process while safeguarding against infection and further injury. By understanding the specific benefits of different types of wound dressings, healthcare professionals can optimize the healing process and improve patient outcomes

Methods: This literature review was compiled using information from various open access online databases. Data were collected and analyzed.

Results and Discussions: Honey dressing demonstrates superior efficacy compared to hydrogel dressing in wound management. Its multifaceted properties, such as potent antimicrobial activity, tissue regeneration promotion, and anti-inflammatory effects, render it a superior option for wound healing throughout all stages. Additionally, honey is more cost-effective than hydrogel and more easily accessible.

Conclusion: The efficacy of honey dressing surpasses that of hydrogel dressing in wound management. Honey's multifaceted properties, including its potent antimicrobial activity, ability to promote tissue regeneration, and anti-inflammatory effects, make it a superior choice for wound healing across all phases.

KEYWORDS: honey, hydrogel, wound healing

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INTRODUCTION

The wound healing process consists of several stages, including inflammation, proliferation, and remodeling. During the inflammatory phase, various cells and factors work together to initiate the healing response and remove any potential pathogens. During the proliferation phase, the wound is rebuilt with new tissue made up of collagen and extracellular matrix components, while in the remodeling phase, the wound undergoes further strengthening and reorganization of the newly formed tissue. It's important to understand that the application of different wound dressings can significantly impact the progression of these wound healing phases.[1]

Wound dressing is a fundamental aspect of modern healthcare, encompassing a diverse range of materials and techniques aimed at optimizing the healing process while safeguarding against infection and further injury. From minor cuts and abrasions to complex surgical wounds and traumatic injuries, effective wound dressing plays a pivotal role in promoting tissue repair and restoring skin integrity. Wound dressing is a crucial component of wound care that aims to promote healing, prevent infection, and protect the wound from further damage.[2]

It is vital to recognize the significance of wound dressings in facilitating the wound healing process. The appropriate selection and application of wound dressings can significantly impact the different phases of wound healing, namely inflammation, proliferation, and remodeling. It also play a crucial role in providing the ideal environment for wound healing by maintaining moisture, controlling infection, and promoting tissue regeneration. By understanding the specific benefits of different types of wound dressings, healthcare professionals can optimize the healing process and improve patient outcomes. There are several type of wound dressing such as honey and hydrogel.[3]

Honey wound dressings have demonstrated effectiveness in

promoting the proliferation phase of wound healing by creating a moist environment and reducing inflammation. Their antimicrobial and anti-inflammatory properties contribute to their success in facilitating wound healing. Similarly, hydrogel-based wound dressings excel in maintaining a moist environment, reducing pain, and supporting autolytic debridement during the inflammatory phase. Additionally, they offer a protective barrier against bacterial invasion and external contaminants, there by promoting the proliferation phase of wound healing.[4]

Hydrogels have emerged as the preferred material for wound dressings due to their exceptional hydropathic properties, biocompatibility, and resemblance to the extracellular matrix (ECM). Their hydrophilic nature enables efficient absorption of wound exudate, while their three-dimensional pore structure facilitates cell migration, proliferation, and tissue regeneration. Consequently, hydrogels have gained popularity in wound management. In recent years, there has been a growing interest in hydrogel wound dressings that not only fulfill wound monitoring functions but also offer treatment capabilities.[5] This is because they can assess the wound microenvironment and provide treatment as needed. For this reason, we aim to compare the efficacy of honey versus hydrogel for wound dressing to enhance the healing rate.[6]

METHODS

We conducted this literature review by analyzing data from various web databases. Inclusion criteria consist of: (1) selecting journals that were openly accessible, and (2) choosing articles that matched the subject matter covered in this review. For this literature search, we utilized keywords such as "honey dressing for wound healing", "hydrogel dressing for wound healing", and "efficacy honey dressing vs hydrogel for wound healing" on platforms including PubMed, Google Scholar, and Elsevier. We collected, organized, and summarized the data obtained from these sources.

REVIEW RESULTS AND DISCUSSIONS

HONEY-BASED WOUND DRESSINGS

Throughout history, diverse cultures have utilized honey for medicinal purposes, recognizing its antimicrobial and regenerative attributes. The ancient Egyptians employed honey to treat wounds, a practice validated by experimental evidence demonstrating its effectiveness in healing and infection prevention.[7] Honey has a long history of use for its medicinal properties, particularly in wound healing applications. Studies have shown that honey dressing is effective in promoting wound healing, sterilizing wounds, preventing hypertrophic scarring, reducing the need for debridement, and improving overall outcomes compared to other traditional wound dressings.[8] The antibacterial properties of honey have been demonstrated to effectively manage wound infections and accelerate the healing process. Honey dressing has also been found to enhance granulation, epithelialization, and reduce hypertrophic scars and contractures in burn patients.[9]

The extensive exploration of natural antimicrobial properties of honey, including its ability to prevent wound infections and promote wound healing, encompasses factors such as hydrogen peroxide (H_2O_2) production, osmotic effects, and polyphenols. These antimicrobial attributes are essential for the body response to tissue damage. Harmful protein-digesting enzymes produced by bacteria can impede tissue regeneration by interfering with the production of growth factors and the extracellular matrix (ECM).[10] Additionally, bacterial consumption leading to reduced oxygen availability can hinder tissue growth. Thus, the removal of bacteria from the wound site can facilitate tissue regeneration. Furthermore, honey possesses properties that support the regeneration of damaged tissue and wound healing, which are influenced by various factors such as moisture, pH, sugar content, reactive oxygen species (ROS) generation, and anti-inflammatory effects. These characteristics collectively contribute to the 4 stages of the wound healing process: hemostasis, inflammation, proliferation/epithelialization, and tissue remodeling (see **Figure 1**).

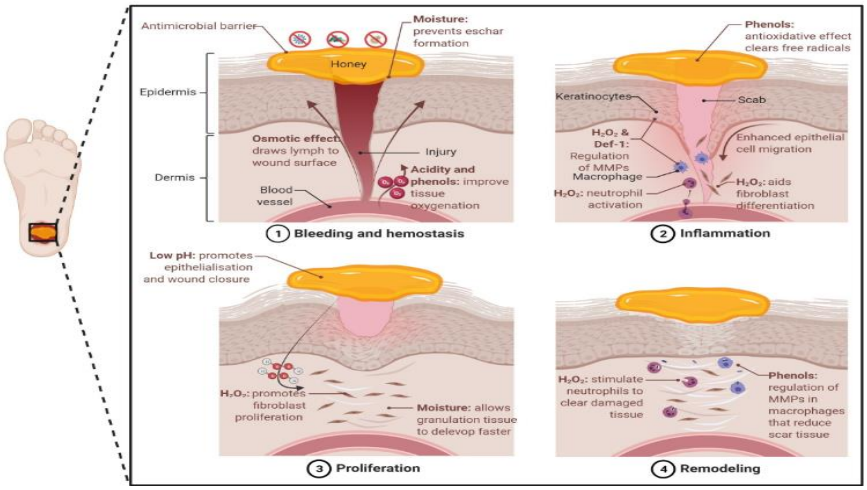

Figure 1. Crucial factors inherent to honey that contribute to wound healing throughout 4 phases of healing wound.

HYDROGEL-BASED WOUND DRESSINGS

Hydrogels are polymer networks that are cross-linked in three dimensions and consist of hydrophilic polymers such as agarose, alginate, carboxymethyl cellulose, or collagen for creating high water content. They are biocompatible, as they are structurally resembling the structure of the extracellular matrix (ECM). Hydrogels preserve the damp environment of a wound by supplying water molecules directly to it. They are used for many different types of wounds, acute or chronic, including leg ulcers and pressure sores. Hydrogel dressings are available as amorphous (shapeless), impregnated into a secondary dressing such as gauze or foam and as sheets.

Hydrogel dressings can be categorized based on the type of polymer utilized, into natural and synthetic, or depending on the substances incorporated, into inert and active. Natural hydrogels are derived from materials such as chitosan, cellulose, alginate, dextran, or hyaluronic acid. Alternatively, hydrogels can be synthesized from polymeric chains such as polyacrylamide, polyethylene oxide, or polyvinylpyrrolidone (PVP).[11]

Mechanism of action regarding hydrogels as dressing to facilitate wound healing is based on the covalent bond. Hydrogels are categorized as either “reversible” or “physical” hydrogels when their structural integrity is upheld by molecular entanglements or ionic or hydrogen bonds. Alternatively, they are classified as "permanent" or "chemical" hydrogels if composed of covalent bonds. These networks have the potential to expand with water until reaching equilibrium while retaining their original structure. As a result, they possess a significant capacity to absorb exudates from the wound environment, enhance oxygen flow, and maintain elevated moisture levels at the wound site. This fosters an accelerated healing process. Hydrogels possess biodegradability and biocompatibility, making them suitable as temporary templates during chronic wound re-epithelialization and remodeling. Their adequate bioadhesivity ensures sustained stability, vital for promoting hemostasis and maintaining optimal wound moisture levels. Additionally, hydrogels offer versatility by accommodating various components such as antibacterial agents, drugs, and biomolecules, enhancing their overall efficacy in wound healing. In summary, hydrogel-based materials are the optimal choice for wound dressings due to their comprehensive benefits in covering skin wounds.[5]

Another crucial aspect of hydrogels is their ability to mimic the extracellular matrix (ECM), which is essential for cellular adhesion, tissue anchorage, cellular signaling, and cell recruitment. The extracellular matrix (ECM) is primarily composed of polysaccharides, proteins, and water. In cases of acute or chronic injury, the extracellular matrix (ECM) may suffer significant damage. Hydrogels will replicate the stiffness of the extracellular matrix (ECM) as they consist primarily of water and polymers. Moreover, they can imitate extracellular matrix (ECM) functions by integrating cells and other macromolecules found in the extracellular matrix (ECM).[12] Essentially, when applied to a wound, hydrogels serve as a dermal matrix, imitating the structure and function of uninjured skin, potentially preventing scar formation by approximating the tensile contraction and elastic retraction strength of intact dermis. This is believed to foster cell development, extracellular matrix (ECM) deposition, and tissue regeneration, thus promoting wound healing. Hydrogels made from hyaluronic acid, collagen, and alginate have shown particular effectiveness in creating extracellular matrix (ECM)-like matrix.

The advantages of using hydrogel as a wound dressing are manifold. Hydrogels are biocompatible and possess the ability to absorb fluids and debris from wound areas effectively. They demonstrate flexibility and elasticity at temperatures higher than their glass transition temperature, while also being capable of absorbing significant amounts of water and swelling. Additionally, hydrogels exhibit responsiveness to various parameters such as temperature, acidity (pH) level, glucose levels, and magnetic fields, allowing for tailored therapeutic effects. By modulating these parameters, hydrogels can release bioactive molecules specific to the application, offering versatile and targeted wound healing solutions.[13]

Hydrogels are widely known for their ability to maintain a moist wound environment, offering a cooling sensation upon application that can help alleviate inflammation. However, their high water content consequently results in a limited absorptive capacity and often necessitates frequent dressing changes to prevent saturation and ensure continued effectiveness. A downside of hydrogel is its limited ability to absorb excess fluid from wounds, which can lead to problems like overly wet skin (maceration) around the wound (periwound) making it prone to damage and infection. Additionally, the accumulated fluid creates an ideal environment for bacterial growth, increasing the risk of infection and potential complications. Despite benefits of hydrogels in keeping wounds moist and cool, their poor absorption capacity may cause issues such as skin softening and bacterial proliferation if not properly managed.[14]

COMPARATIVE ANALYSIS OF HONEY-BASED AND HYDROGEL-BASED WOUND DRESSINGS

Antibacterial effect between honey and hydrogel has significant differences. Certain hydrogel materials, like chitosan and modified chitosan, possess inherent antibacterial properties. However, they may not be highly effective as independent antimicrobial agent and therefore, the addition of antimicrobial active ingredients becomes necessary to achieve an optimal antimicrobial efficacy. The most common solution is to load antimicrobial agents, antibiotics, and/or metal nanomaterials like silver nanoparticles into the

hydrogel to treat the infection at the wound site. There have been reports of an antibacterial hydrogel developed by combining vancomycin with silver nanoparticles. Scientists also tried loading Zinc oxide (ZnO) nanoparticles in a hydrogel to endow it with the antibacterial ability.[15]

Meanwhile, honey showcases an impressive antimicrobial effect owing to its distinctive composition and properties. One key aspect is its broad-spectrum activity, meaning it can combat a wide array of bacteria, including both Gram-positive and Gram-negative strains, even those resistant to antibiotics and forming biofilms. This versatility renders honey a valuable natural antimicrobial agent. A significant contributor to its antimicrobial prowess is the production of hydrogen peroxide (H_2O_2) through enzymatic processes. Most honey varieties generate hydrogen peroxide thanks to the action of the enzyme glucose oxidase, which hampers microbial growth effectively. Moreover, besides hydrogen peroxide, honey harbors non-peroxide factors like low water activity, acidity, phenolic compounds, defensin-1, and in specific types such as Manuka honey, methylglyoxal. These components collectively contribute to honey's antimicrobial potency, enhancing its ability to combat infections and promote wound healing.[7]

In terms of costs, a study in Cipto Mangunkusumo National General Hospital by Putri and colleagues, focusing on the monthly cost of standard wound care, include dressing, usage, and related wound care based, showed the mean monthly cost of IDR 943,906 in the honey dressing group compared to IDR 1,526,113 in the hydrogel dressing group, although this disparity did not reach statistical significance ($p = 0.212$). Specifically, the mean wound dressing cost in the hydrogel group was Rp 580,272, while in the honey dressing group it was Rp 74,925. The total cost was lower in the honey dressing group than in the hydrogel dressing group. Notably, a single bottle of honey dressing, whether 250 ml or 650 ml, proved to be more cost-effective and could be utilized for multiple dressing changes, despite the daily frequency of changes. These cost differences were starkly different from those reported in another study, where treatment costs ranged from $20,000 to $70,000 per wound. This study doesn't account for hospital inpatient costs, diagnostic and treatment expenses related to underlying diseases and comorbidities, as specifically aimed to isolate and compare the costs of dressing and related commodities, such as consumables and outpatient dressing change expenses.[16]

The requirements for ideal wound dressings should include the ability to maintain moist, clean, and warm wound environments, remove exudates, provide barrier against external pathogens, facilitate easy application as well as painless removal, enable cavity filling, maintain no damages to perilesional tissue, and ensure adequate hydration and gas exchange.[17] Based on that criteria, hydrogel-based wound dressings are widely adopted in various wound care treatments owing to their unique absorption capability, their ability to facilitate gas exchange (including oxygen, carbon dioxide) and water, and capacity to minimize patient discomfort during removal. Furthermore, they contribute to tissue granulation and have the potential to reduce the wound bed temperature by up to 5°C. With their high hydrophilic nature, comprising 80–90% water content, hydrogel dressings can sustain a moist wound environment, thereby promoting autolytic debridement. However, hydrogel dressings still demonstrate inferior efficacy in combatting bacterial contamination than honey, as hydrogel dressings usually requiring supplementation with antimicrobial agents.[18]

Patient satisfaction regarding application of hydrogel versus honey as wound dressings vary based on individual experiences and preferences. Some patients may find hydrogel more comfortable and easier to apply due to its gel-like consistency, which can provide a soothing sensation and maintain a moist environment conducive to healing. Hydrogel dressings are also typically non-adherent, minimizing pain during dressing changes. On the other hand, patients may appreciate the natural properties of honey, such as its natural antimicrobial and anti-inflammatory effects, which can promote wound healing and reduce the risk of infection. Additionally, some patients may prefer honey due to its perceived effectiveness in managing wound odor and promoting granulation tissue formation. Ultimately, patient satisfaction with either hydrogel or honey as wound dressings may depend on factors such as the type and severity of the wound, personal preferences, and the overall effectiveness of the chosen dressing in facilitating wound healing and comfort.

Table 1. Literatures search for patient satisfaction on honey versus hydrogel as wound dressing.

Title	Study ID	Results
Application of Honey Dressing on Open Wounds: It's Healing Effect and Satisfaction among Surgical Patients	Abdullah *et. al.*, 2022[19]	In the study conducted, approximately 82.2% of the patients in the study group were satisfied with the use of honey as a wound dressing, while only about 17.8% of the patients were partially satisfied. None of the patients were dissatisfied with the use of honey as a wound dressing.
Comparative evaluation of hydrogel dressing with	Chandel *et. al.*, 2017[20]	The study found similar wound reduction effectiveness, with an average wound size decrease

conventional dressing in diabetic foot ulcers		of 56% compared to 29% in the conventional dressing group. Most wounds in the VAC group healed within 7 weeks. Patients in the VAC group reported excellent satisfaction levels compared to those in the conventional dressing group.

FUTURE DIRECTIONS AND RECOMMENDATIONS

While existing research has shed light on the effectiveness of these dressing types, further studies are imperative to comprehensively elucidate their comparative effectiveness in promoting each phase of wound healing. Future research should take into account factors such as wound type, patient demographics, and specific wound healing objectives to provide valuable insights into the optimal use of wound dressings for enhanced outcomes. By acknowledging the significance of customized wound care and the importance of tailoring dressing selections to specific wound phases, healthcare professionals can effectively optimize the healing process and improve patient outcomes. One innovation in wound dressing involves combinations like honey-based hydrogel. It involves continuous innovation and interdisciplinary collaboration to create next-generation dressings that offer superior antimicrobial activity, enhanced mechanical properties, and personalized treatment options for improved wound care outcomes.

CONCLUSION

The efficacy of honey dressing surpasses that of hydrogel dressing in wound management. The multifaceted properties of honey, including its potent antimicrobial activity, ability to promote tissue regeneration, and anti-inflammatory effects, make it a superior choice for wound healing across all phases. Furthermore, honey represents a more cost-effective and readily available choice compared to hydrogel. Thus, the utilization of honey presents overall greater advantages than hydrogel. In contrast, while hydrogel dressings provide moisture retention and facilitate a conducive environment for wound healing, they lack the comprehensive benefits and therapeutic efficacy exhibited by honey dressing. Thus, considering the holistic advantages and clinical outcomes, honey dressing may emerge as the preferred choice for wound care interventions.

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