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Review Article

A Comprehensive Review on Wound Dressings and Their Comparative Effectiveness on Healing of Contaminated Wounds and Ulcers

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ABSTRACT

Any accident or operation can result in a wound. In general, bleeding wounds, chronic wound and infectious wounds require special attention for retrieval and wound recovery and management. In the case of germ infection, this is a difficult procedure. The proper management of wound procedures includes initial cleaning, wound healing, infection prevention, germ treatment and dressings. In the process of wound healing and infection prevention, wound dressings play a vital role. A contaminated wound is defined as one that has been exposed to germs and foreign particles but has shown no evidence of infection. Multiple pathogens or infectious organisms are present in the wound, which is known as a chronic wound. This arises frequently in patients who have diabetic feet and pressure ulcers. As a result, diabetes management necessitates a rapid acceleration of foot ulceration. There is no single dressing that can fulfil all of the needs of a patient with an infected foot ulcer or other contaminated wounds. However, each dressing type has a different aid in selecting it. Wound dressings, such as foam and alginates, are very absorbent and useful for wounds that are heavily oozing. As a clinician, he has to deal each and every day with numerous patients with various types of wounds, such as acute, chronic, burn and foot ulcer conditions. Hence, it is very essential and helpful to have proper knowledge about the right type of dressing for a particular wound and also the right time for wound dressings for patients' prognosis from illness. In this present review, we will discuss the various wound dressings and their comparative effectiveness on contaminated wounds and ulcers.

Skin is the largest organ in the human body, with abundant and complex functions necessary for our survival. The chief function of the skin is to act as a protective layer or barrier against the external environment. Skin plays a protective role against various harmful chemicals, pathogenic organisms and ultraviolet radiation, as well as it can synthesize Vitamin-D, regulate body temperature and loss of moisture [1]. Wounds are caused by injuries or damage to the skin layers and tissues. There are two types of wounds: open and closed. Depending on an individual's health situation, they might have acute or chronic (non-healing) wounds. To repair the damage, an organized sequence of biological activities is constructed. Because wound healing is a complex and detailed process, the damage to the skin exposes it to a particular challenge. Burns are estimated more than $7.5 billion annually [2-3]. With chronic skin ulcers $50 billion people suffer from due to pressure, venous stasis, or diabetes, it's no surprise that cutaneal wound healing has become a hot issue of research and

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debate around the world. An additional factor to consider while treating these wounds is the cost-effectiveness of various treatment regimens.

Patients are seen in a variety of places and many of them fail to enter the health care system, so exact expenditures are uncertain due to the difficulties in acquiring correct data. The healthcare system is under tremendous pressure to create cost-effective treatments [4]. Wounds, as is well known, require complex and delicate connections that successfully transition the wound from an acute inflammatory phase to the subsequent proliferation and remodelling stages. When optional local and systemic circumstances do not exist, aberrant wound healing occurs, resulting in a "non-ideal" wound-healing environment [5]. When acute wounds are not treated, they turn into chronic wounds, requiring the physician to have a complete grasp of external interferences in order to return these wounds to the healing cascade. The various wound dressings and their comparative effectiveness on contaminated wounds and ulcers were discussed in this review.

Classification based on type of wound

Thickness of wound

- Shallow wound involves the epidermis and dermal papillae.
- Partial thickness of wound- with skin injury up to deep dermis.
- Complete thickness damage of whole skin and subcutaneous tissue.
- Deep wounds spreading across profound fascia into muscles.
- Complex wounds harming nerve or vessels.
- Penetrating wound damaged to cavities/organs.

Table 1- Classification based on surgical wound

Sr. no.	Type of surgical wound	Causes
1.	Clean wound	Non-tranumatic, elective surgery, herniorrhaphy,excisions
2.	Clean contaminated wound	Appendicectomy,bowel
3.	Contaminated wound	open fresh accidental wounds,burst appendicitis.
4.	Dirty infected wound	Faecal peritonitis, empyema gallbladder.

Categorizations of wounds

1) Acute Wounds: Acute wounds follow regular stages of healing and show signs of healing in less than 4 weeks, e.g., surgical or traumatic wounds.

2) Chronic wounds: Chronic wounds do not heal normally and show no signs of healing after four weeks. The main causes, such as diabetes, venous or arterial illness and dietary deficits.

Wound healing, complications

Wound healing: Proliferation, inflammation, and remodeling represent three overlapping and intermittent phases in wound healing.

In the process of wound healing, proliferation, inflammation and remodelling represent three overlapping and intermittent phases. Chronic wounds are those that are stuck in the healing process and are unable to proceed and those that are still unhealed after four weeks are categorised as chronic.

Mixed roles of bacteria in wound

Due to the metabolic load carried out by bacteria, wounds that have reached critical colonisation by pathogens have a reduced potential to heal. Some metalloproteinases are essential for wound healing. All wounds enclose proteolytic enzymes that promote cell migration, regulate physiologically active chemicals, and aid in the remodelling of extracellular materials. These enzymes can be overproduced in chronic wounds with excessive exudates, causing premature fibronectin and collagen breakdown [7] is critically colonized, the replicating number of bacteria becomes a bioburden and delays wound healing. Wounds typically become bacteria-infested and are frequently polluted within 48 hours. In terms of bacterial production, wounds can be classified into four categories. The bacteria that infect wounds are in small numbers and do not proliferate. Microflora clinging to the host surface of colonised wounds multiply and form colonies. There is no overt hostility in the current situation. When a wound becomes critically colonised, the number of reproducing bacteria forms a bioburden, which delays wound healing.

Secondary signs and symptoms of infection, such as increased serous exudates, friable granulation tissue, a change in granulation tissue appearance to bright red, pain at the wound site, enhanced or unusual wound odour and wound collapse caused by deficient tissue, are multiplying and eliciting a host reaction this time. Fever, warmth, edoema, swelling, discomfort, erythema and purulent excrement are all common signs and symptoms. Infected wounds will have a colony forming bacterial unit density of more than 10 per cubic millimeter of tissue. [6,8]. "Bacterial bioburen" denotes the metabolic activities of bacteria, such as poisonous components and the negative effects of the host's inflammatory response [6,8]. In particular, in chronic wounds, the bacteria are identified to form a protective coating, called "biofilm." This protective coating goes unrecognised by host defence mechanisms and is resistant to most topical antimicrobials. Therefore, wound debridement is of primary importance, as it disrupts the wound film and

allows the infusion of host cells and interactive materials from the dressings.

Wound dressing:

Traditional wound dressing treatment:

To treat a wound appropriately, the technique of wound dressing depends on whether the lesion is a minor cut or a severe incision. Thousands of people perish annually as a result of numerous skin injuries or skin burns caused by flames, accidents, or boiling oil and water, which often result in process-related disability or even death [9-10]. Wet-to-dry dressings have been extensively used for wounds requiring debridement since ancient times. Linen strips drenched in oil or grease and wrapped in plaster were used to occlude wounds around 1600 BC.

Clay tablets of Mesopotamian provenance were used to cure wounds starting around 2500 BCE. They used water or milk to clean the wounds. Following that, the wound was dressed with resin and honey. In 460–370 [11], vinegar or wine was used to clean wounds from ancient times. Later on, the antiseptic technique evolved significantly by introducing antibiotics to control infections, similarly, modern wound dressing techniques were introduced in the 20th century [12]. Later, occlusive dressings were created to keep the wound wet and hence protect it. Occlusive dressing treatments have been found.

To stimulate collagen synthesis, promote re-epithelialization and decrease wound bed pH, which prevents infection. To cover superior wounds in 1891, cotton gauze was made. Thus, they have long been used as traditional wound dressings. These absorb the wound's fluid content and thoroughly dry the wound's surface, thereby showing healing and increasing discomfort while removing the dressing. In 1948, the moist chamber effect was illustrated by Oscar Gilje. The first advanced wound dressing was developed in the mid-1980s and included vital features such as providing a wet environment and absorbing fluids. In the wound healing process, synthetic wound dressings have evolved into a variety of products such as hydrogels, foam vapor-permeable films, alginates, tissue adhesives, and silicone meshes that deliver optimum conditions [13-15].

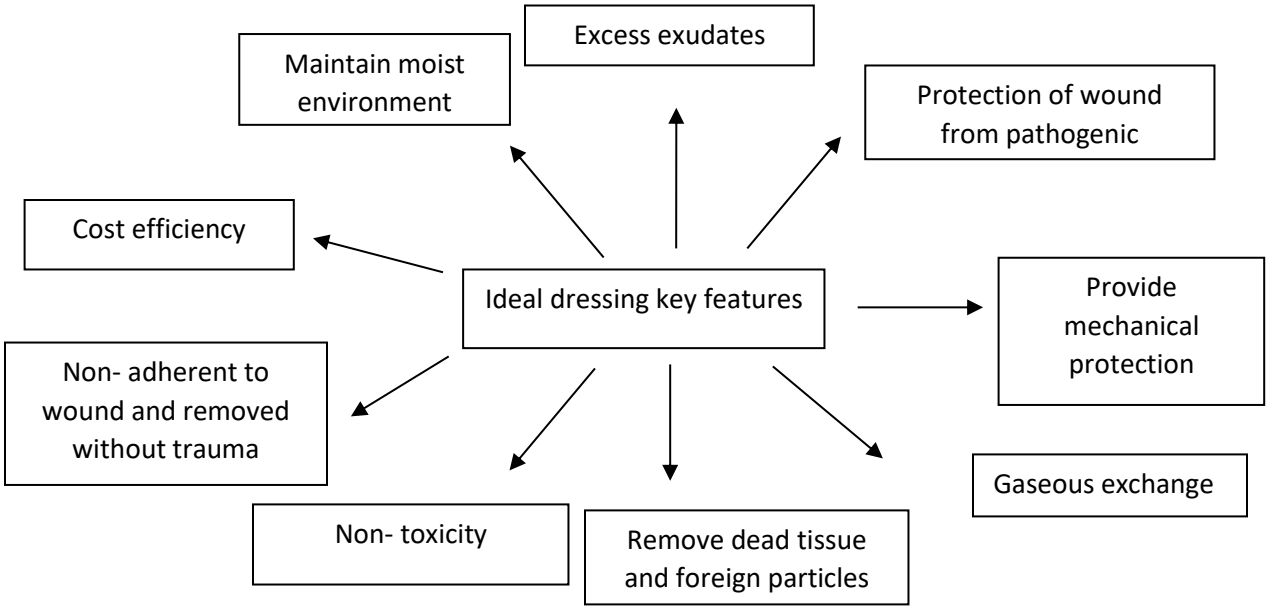
The selection of a wound dressing depends on the type, depth, location, and extent of the wound. Traditional wound dressings wick moisture away from the wound, causing it to dry. For example, cotton bandages and gauze dressings. A variety of polymers in the form of biofilms, foams and gels have been developed to provide a favourable environment for wound healing [16-18].

Features of Ideal dressing:

Consequently, numerous materials have been used to treat wounds, since ancient times in an attempt to control bleeding, absorb exudates and promote healing. Honey, animal oils or fat, cobwebs, mud, leaves, sphagnum moss, or animal bones. [8]. While, the majority of these readily available natural ingredients were eventually shown to be ineffective, including honey, research [8]. There is a need to change the dressing type as the wound environment changes.

Nowadays, the number of wound dressings available on the market has increased. This represents a lack of comprehensive knowledge of wound care and management. The purpose of advanced dressing is to increase certain wound characteristics such that they are as close to "perfect" as feasible. The 'perfect' dressing can only be chosen after a thorough examination of the wound's features and a thorough understanding of the numerous products.

Figure 1- An ideal wound dressing should follow the above mentioned characteristics.



Classification of Wound Dressings

According to their function, dressings are classified as antimicrobial, absorbent, occlusive, adherent and debridement. Dressings come in a variety of physical forms, such as ointment, film, foam and gel. Based on the origin of materials, dressings are divided into three groups, which include animal origins, herbal origins, and synthetic origins [19-20]. In the following sections, we define and review the following groups: animal origin dressings, herbal origin dressings, and other types of dressings.

Animal Origin Dressings: Animal origin dressings are intended to improve wound healing or reduce healing time. It can also be used to debride the wound, absorb exudate and offer topical medicines. Some topical agents improve wound healing, including honey, silver, other antimicrobials, or any other agent [20].

Herbal Origin Dressings

On the basis of ancient literature, for a wide range of illnesses, medicinal plants play a vital role as natural medicine for treatment. Medicinal plants have traditionally been used to treat a variety of wounds and skin infections. Natural herbal dressings are non-toxic in nature and can be used for a long period of time [21-22]. In comparison with other dressings, herbal dressings have a unique structure [20]. Plants such as cotton, viscous, or a combination of the two have been used to make an abundant number of burn dressings. In several studies, it has been concluded that the Hypericum perforatum, which is commonly known as St. John's wort (SJW), has a long and illustrious history as one of the most extensively used and studied therapeutic herbs. These natural herbal plants have antiviral, anti-inflammatory, and antibacterial properties.

Modern wound dressings with the Synthetic/advanced origin

Modern wound dressings are designed to simplify the function of the wound rather than to cover it. The purpose of these dressings is to keep the wound free from moisture and to promote healing. In the market, there are a number of products available, but the selection of products on the basis of cause and type of wound is a very difficult task [23]. Modern wound dressings are often made of synthetic polymers and are divided into three categories: passive, interactive and bioactive.

Non-occlusive or passive products including gauze and tulle dressings, are used to cover the wound in order to improve its function underneath.

Occlusive or semi-occlusive dressings are interactive dressings that exist in film, hydrogel, or hydrocolloid form. These dressings serve as a barrier against bacterial infection in the wound environment [8]. In the cases of skin injuries, dressings are used as medicated dressings and non-medicated dressings.

Non-medicated dressings illustrated as follows

Non-medicated Dressings: Non-medicated dressings are usually made up of hydrocolloids and alginates, which exist in the form of films, gels, and laminar foam. This type of dressing is distinguished by its ability to provide a wet wound bed, which aids wound healing.

1) Semi-permeable film dressings

These dressings are made of a transparent and adherent polyurethane that allows transmission of water vapor, oxygen and carbon dioxide from the wound as well as autolytic debridement of dead skin and microbial resistance [24]. Initially, occlusive films were made out of nylon derivatives with adhesive polyethylene frames as a support. Previously, nylon resulting film dressings were not used for highly exuding wounds due to their weak absorption capacity, which caused maceration of the lesion and surrounding healthy tissues [23]. Semi-permeable dressings are extremely elastic and flexible. Therefore, dressings like Opsite, Tegaderm and bio-oclusive are indorsed for epithelializing wounds, superficial wounds and shallow wounds with minimal exudates. Film dressings diverge in terms of their adhesive features, conformability, vapour permeability and extensibility [25].

2) Semi-permeable foam dressings

The hydrophobic and hydrophilic foams are used to create foam dressings with adhesive borders [26]. The outer hydrophobic layer protects against liquid but permits the exchange of gaseous and water vapor. Based on the wound thickness, foam has the ability to absorb large amounts of wound drainage. These dressings are effective for lower leg ulcers as well as for extremely exuding wounds. The hydrophobic and hydrophilic foams are used to create foam dressings with adhesive borders [26]. The outer hydrophobic layer protects against liquid but permits the exchange of gaseous and water vapor. Based on the wound thickness, foam has the ability to absorb large amounts of wound drainage. These dressings are effective for lower leg ulcers as well as for extremely exuding wounds. Generally, these dressings are used as primary dressings for absorption and secondary dressings are not necessary due to their high absorbance and moisture vapour permeability [26-27]. Numerous dressings are disadvantages of foam dressings and are suitable for minimal exudating wounds, dry scars, and dry wounds as they depend on exudates for their healing. Rather than these, one other disadvantage is its very painful treatment, e.g. Lyofoam, Allevyn and Tielle [26,28].

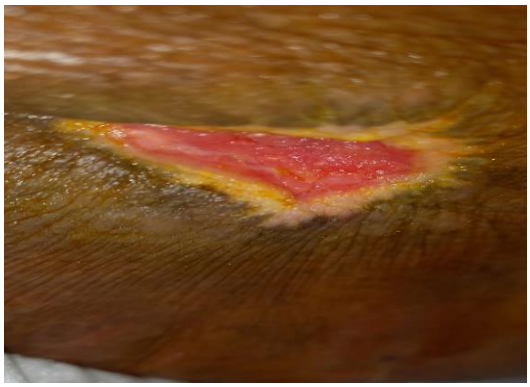
3) Hydrogel Dressings

These dressings are composed of hydrophilic, inflated, and insoluble polymers that appear in the form of gels and films. Hydrogel dressings contain 70 to 90% water, so they are capable of absorbing huge numbers of ulcers and are suitable only for the surface of wounds. Hydrogel dressings are helpful for dry chronic wounds because they remove dead tissues and foreign material from the wound [29].

Also, these dressings are useful for dry, pressure ulcers, necrotic and burn wounds. Furthermore, wounds with

low exudate control with hydrogel dressings are one of the best choices. Furthermore, these dressings are useful for painful wounds [30]. According to Fan et al., Poly Vinyl Alcohol (PVA) is a commonly used polymer in the form of a hydrogel due to its excellent biocompatibility, which makes it suitable for a wide range of biomedical applications, particularly wound dressings [31].

Figure 2- (A) Chronic wound before treatment. (B). Hydrogel used as packing in an infected and irregularly shaped wound of the lower extremity.



A

B

4) Hydrocolloid dressing

These dressings are most commonly utilised as co-operative dressings and consist of two layers: the inner layer, which is a colloidal layer and the outermost layer, which is a water-impermeable layer. Gel-forming agents such as carboxymethyl cellulose, gelatin, and pectin are combined with other substances like elastomers and adhesives to make hydrocolloid dressings [16]. Hydrocolloid dressings are permeable to water vapour but impermeable to pathogens. They also have debridement properties and the ability to absorb wound exudate [27]. These dressings are helpful for light-to-moderately mucous wounds, including pressure sores, minor burns and traumatic wounds. Since they're recommended for paediatric wound care management, these dressings do not cause any pain on removal. When these hydrocolloids come into contact with wound exudate, they form gels and give moist surroundings, which aids in granulation tissue and protection via absorbing and holding exudates [32,33,34]. Hydrocolloids are mostly used as secondary dressings and these dressings have the disadvantage of not being advised for neuropathic ulcers or wounds with a highly exuding surface [16].

5) Alginate dressing

Alginate is a widely utilised ionic polysaccharide that is employed in the design and development of various dressings to increase the efficacy of wound healing [35]. The absorption competence is achieved by strong hydrophilic gel formation, which controls wound exudates and decreases bacterial contamination. Some studies emphasise that alginate inhibits keratinocyte migration. Alginates, according to Thomas et al., can regulate wound healing by converting macrophages to Tumor Necrotic Factor (TNF-), which initiates inflammatory signals [26]. Once alginate dressings are applied to the wound; the ions in the alginate are replaced with the blood to form a protective film. These dressings are useful for moderate to heavy drainage wounds and are not recommended for dry wounds, third degree burn wounds, diabetic ulcers and severe wounds with open bone. Alginate dressings are made from soft, non-woven alginic acid fibers, a cellulose-like polysaccharide resulting from seaweed, coated in Ca and Nacl, as reported by Rahmani S et al., [26] At the time of interaction with wound exudates, alginate dressings have the capacity to form gels, which makes dressing removal easier [36].

Silver dressings: Silver ion dressings are topical wound care products resulting from silver ions. From thousands of years, silver has been used in medicine for its antimicrobial or antibacterial properties. Based on the amount of exudate and pathogens in the wound, silver is activated from the dressing to the wound's environment.

In 1617, John Woodall first documented silver use in surgical patients [8]. Generally, silver is used in many dressings and topical agents. The antimicrobial properties of silver make it effective against microorganisms, fungi, viruses and yeast.

Silver has also been shown to be effective against Methicillin-resistant Staphylococcus aureus (MRSA) and vancomycin-resistant enterococci (VRE) when applied at the appropriate concentration because it reduces wound inflammation and aids healing [37].

Polyhexamethylene biguanide and honey dressings

Polyhexamethylene biguanide (PHMB) is a wound care antiseptic that has recently attracted interest from wound care practitioners. Although, it has a long history of use in things like contact lens cleaning solutions and wet wipes, etc. PHMB exists as a cleansing solution as well as a bio-cellulose dressing [38]. These dressings are effective against a broad spectrum of pathogens, fungi, molds, yeasts, MRSA and VRE. In a 28-day assessment, Eberlein et al. compared treatment with a PHMB containing biocellulose wound dressings against silver dressings. The PHMB-biocellulose group exhibited a

much faster reduction of critical colonisation and local wound infection than the silver treated dressings. These groups show a p 0.001 statistically significant association between them [39]. These groups were more effective in reducing pain and bacterial burden. Moreover, the PHMB group was significantly faster and easier in eliminating the critical bacterial load. Manuka honey is an ancient remedy for the treatment of infected wounds and was first documented as a topical antibacterial agent in 1892 [39]. Some studies have reported the effectiveness of honey products in the wound healing process [40]. Some evidence reports that honey can inhibit biofilms of numerous species.

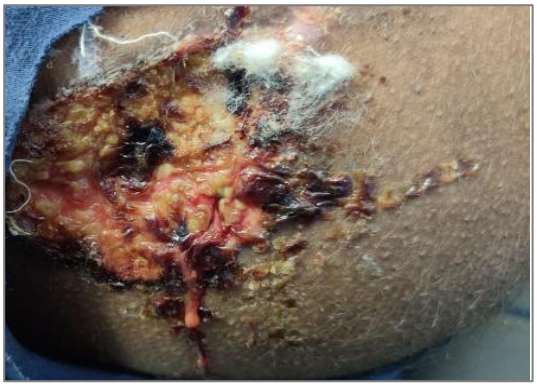
Honey may also have a role in lowering odour, establishing an autolytic debridement in which hone's osmotic action stimulates exudates to move away from the wound bed and acting as an anti-inflammatory and immune modifying agent [40].

Iodine dressings

Nowadays, various products are available to clear the infection and promote wound healing. Iodine is one of these products, but assessments are conflicting as to the effectiveness and side effects of iodine in the treatment of wounds [8]. For example, Cadexomer iodine treatment, which is available in the form of gel, powder, and ointment. Cadexomer iodine treatments are available in a variety of forms, including ointments and powders. These products absorb fluids, removing exudate, pus and debris. Iodine dressings slowly kill microorganisms and form a protective gel film over the wound environment [42].

For the treatment of chronic, non-healing wounds such as leg ulcers (venous, arterial and mixed aetiology), pressure ulcers and exuding, contaminated wounds, diabetic ulcers similarly, infected traumatic and surgical wounds Cadexomer iodine dressings are generally used [41].

Figure 3- (C). A chronic lower extremity of wound. (D). Iodine dressing used to cover a chronic wound with cadexomer iodine based products absorb fluids, removing exudate, pus and debris.



C

D

Figure 4- Chronic wound treated with Betadine dressing.

Advantages:1) It promotes clean wound-healing environment. 2) It reduces no. of dressing changes. 3) Reduces odor in heavily contaminated wounds. 3) Accelerates healing rate, leading to early patient discharge.

Oxum Spray is a super-oxidized solution that can be used locally. It's designed to help debride and irrigate acute and chronic wounds, ulcers, cuts, abrasions, and burns. Oxum Spray reduces inflammation and promotes faster wound healing.

Figure-5 (E). A chronic non- healing wound of the posterior area. (F) Show same wound heal with super oxide spray (Oxum) which reduces inflammation of wound.

E

F

Novel technological innovation in the therapy of chronic wounds that is effective and well tolerated. The solution is steady, non-flammable and non-corrosive bactericidal, virucidal, fungicidal and sporicidal solution that needs no further dilution. Topical treatment of chronic wounds.

Conclusion

A comparative effectiveness study can be used to evaluate topical therapy for wound care and management. In this comprehensive review, we included many classes of wound dressings, including topical pharmaceutical agents, traditional wound dressings and modern wound dressings such as hydrocolloids, alginates, hydrogels, polyurethane film, silver dressings, foam and novel biomaterials such as Dexadine, Cadomer, and oxum, which effectively address time models for skin replacement or wound healing processes.

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