Principles of Wound Dressings: A Review

ZAIDAL OBAGI, MS
MEDICAL STUDENT
UNIVERSITY OF TOLEDO COLLEGE OF MEDICINE AND LIFE SCIENCES
TOLEDO, OHIO

GIOVANNI DAMIANI, MD
POSTDOCTORAL RESEARCH FELLOW
DEPARTMENT OF DERMATOLOGY, CASE WESTERN RESERVE UNIVERSITY
CLEVELAND, OHIO

YOUNG DERMATOLOGISTS ITALIAN NETWORK (YDIN), GISED STUDY CENTRE
BERGAMO, ITALY

CLINICAL DERMATOLOGY, IRCCS ISTITUTO ORTOPEDICO GALEZZI
MILAN, ITALY

DEPARTMENT OF BIOMEDICAL, SURGICAL AND DENTAL SCIENCES, UNIVERSITY OF MILAN
MILAN, ITALY

AYMAN GRADA, MD, MS
DERMATOLOGIST
FELLOW IN CUTANEOUS WOUND HEALING, DEPARTMENT OF DERMATOLOGY
LABORATORY OF CUTANEOUS WOUND HEALING
BOSTON UNIVERSITY SCHOOL OF MEDICINE
BOSTON, MASSACHUSETTS

VINCENT FALANGA, MD, FACP
PROFESSOR OF DERMATOLOGY
DEPARTMENT OF DERMATOLOGY, LABORATORY OF CUTANEOUS WOUND HEALING
BOSTON UNIVERSITY SCHOOL OF MEDICINE
BOSTON, MASSACHUSETTS

ABSTRACT

Dressing is an essential element of standard wound care. The main purpose of wound dressing is: a) provide a temporary protective physical barrier, b) absorb wound drainage, and c) provide the moisture necessary to optimize re-epithelialization. The choice of dressing depends on the anatomical and pathophysiological characteristics of the wound. Contemporary wound dressings provide additional benefits, such as antimicrobial properties and pain relief. In this concise review, we discuss the principles of wound dressing, highlight the features of basic and advanced types of dressings, and offer some practical tips on the choice and application of dressings.
In the 1960s, British researcher George D. Winter (1927–1981) presented a study demonstrating that a moist environment is the optimal environment for wound healing, particularly for chronic wounds, with healing rates three- to five-times faster compared to dry environments. Many studies have since been performed and not only continued to support Winter’s theory but also have shaped the industry of wound dressings and how physicians approach wounds.

It has been noted that increased moisture allows for a more even reepithelialization across the entire wound bed. In contrast, a dry wound, migrating epithelial cells will follow tracks of moisture and may result in uneven and inefficient wound repair. The wound exudate results from vasodilation during the inflammatory phase of wound healing and contains leukocytes, various cytokines, and proteins needed for proper healing. These agents are generally less present in a dry wound bed environment leading to delayed wound healing. A wound that is too wet, however, may also disrupt healing as excess exudate buildup can lead to peri-wound skin maceration and damage. Moreover, it may provide an optimal environment for bacterial colonization. Therefore, an optimized level of moisture is needed for ideal wound healing. It is important that the dressing surface in contact with the wound stays wet, yet also absorbs fluid when exudate is in excess.

A wound dressing is a material applied directly to a wound and, ideally, aims to promote healing or prevent further tissue damage. A good dressing accomplishes multiple goals, including providing an appropriate level of moisture and serving as a barrier to bacterial invasion. Additional benefits of an ideal dressing may include thermal insulation, debridement, enzymatic and growth factor supplementation, gas exchange facilitation, and protection of free nerve endings to reduce pain.

A growing industry has developed around manufacturing wound dressings. The global market for wound care products is currently valued at $7 billion and predicted to approach $22 billion by 2022. Some factors that attributed to this growth include increasing incidence and prevalence of chronic diseases such as diabetes, an aging population requiring increasing medical visits, and a trend to reduce durations of hospital stays and follow ups in outpatient settings.

The general approach for deciding which type of wound dressing to use begins by taking a detailed history and physical exam. It is important to determine if it is draining or non-draining and if it is granular, appropriately healing, or necrotic. A management approach to a non-infected wound is outlined in Table I.

For clinically infected wounds, occlusive dressings are relatively contraindicated, and dressing changes are required more frequently to prevent fluid accumulation. Wounds with a high bioburden, or number of bacteria, have less oxygen and nutrients available for host cells to use during the wound healing process. This may contribute to delayed healing. One may use an antimicrobial dressing empirically until the causative organism is identified. Once identified, the best intervention aimed to reduce the wound’s bioburden should be selected. This may involve continuing antimicrobial dressings, additional debridement, or the use of systemic antibiotics.

It is important to avoid using antimicrobial dressings when not needed, as the antiseptic ingredients can be cytotoxic to host cells, altering cellular function and prolonging the healing process. If the wound is dry, a guiding principle is to select a dressing with moisture to facilitate cell migration and nutrient diffusion and allow for faster healing. If the wound is too wet, selecting an absorbable dressing is indicated with the intention of balancing, but not completely desiccating, the wound surface.

### Table I

Management approach for non-infected wounds

<table>
<thead>
<tr>
<th></th>
<th>Granular</th>
<th>Necrotic</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Draining</strong></td>
<td>● Goal is to protect granulation tissue and periwound area.</td>
<td>● Goal is to debride the wound area, absorb drainage, protect surrounding tissue, and monitor/prevent infection.</td>
</tr>
<tr>
<td></td>
<td>● Use absorptive dressings, gauze, alginates/hydrofibers, semi-permeable foams, or hydrocolloids.</td>
<td>● Use gauze and alginate/hydrofibers, less commonly foam or hydrocolloid dressings.</td>
</tr>
<tr>
<td><strong>Non-Draining</strong></td>
<td>● Goal is to continue proper wound healing. Select a dressing that can balance the right moisture and occlusiveness.</td>
<td>● Goal is to debride carefully, soften eschar, and balance appropriate moisture.</td>
</tr>
<tr>
<td></td>
<td>● Use impregnated gauze, films, and hydrogels.</td>
<td>● Use impregnated gauze, films, hydrogels, and hydrocolloids.</td>
</tr>
</tbody>
</table>
## Table II
Properties of dressing materials and topical agents

<table>
<thead>
<tr>
<th>Type</th>
<th>Actions</th>
<th>Indications/Use</th>
<th>Precautions/Contraindications</th>
<th>Brand Examples</th>
</tr>
</thead>
</table>
| Hydrogels        | Rehydrates wound, balances moisture, and provides a cooling sensation on wounds. | Use on dry to moderately exudative wounds. Can be combined with silver for antimicrobial activity. | Do not use on infected wounds or heavily exudate wounds. Can cause maceration with fluid buildup. | • Tegaderm™ Hydrogel (3M, St. Paul, Minnesota)  
• AquaDerm™ (DermaCare, North Bergen, New Jersey)  
• Kendall™ Hydrogel (Cardinal Health, Inc., Dublin, Ohio) |
| Hydrocolloids    | Absorbs fluid in inner layer, balancing moisture. Can be left on for several days. | Use on dry to moderately exudative wounds. Can be combined with silver for antimicrobial activity. | Do not use on infected wounds or heavily exudative wounds. May cause hypersensitivity reaction, or maceration with fluid buildup. Can promote overgranulation. | • McKesson™ Hydrocolloid (McKesson Corporation, Irving, Texas)  
• Tegaderm™ Hydrocolloid (3M, St. Paul, Minnesota)  
• DynaDerm™ Hydrocolloid (Dynarex Corporation, Orangeburg, Florida) |
| Alginates/ Hydrofibers | Absorbs large amounts of fluid and provides moisture balance to wound bed. Promotes hemostasis and can conform to wounds and be left on for several days. | Use on moderate to heavily exudative wounds. Can be found in rope or ribbon presentation for use in tunneling or deep wounds. | Do not use on dry or necrotic wounds. Do not pack wound bed too tightly as it may desiccate area. May cause lateral wicking and maceration with fluid buildup. | • Maxorb® II Alginate (Medline Industries, Inc., Romulus, Michigan)  
• Aquacel® (ConvaTec Group plc, Bridgewater, New Jersey)  
• Kaltostat Alginate (ConvaTec Group plc, Bridgewater, New Jersey)  
• Cutimed® Alginate (BSN Medical, Charlotte, North Carolina) |
| Foams           | Rapidly absorbs fluid and balances moisture over wound bed. Protects the wound bed from further damage. Does not adhere to wounds. | Use on moderate to heavily exudative wounds. Can be found in rope or ribbon presentation for needed cases. Can be combined with silver for antimicrobial activity. | Do not use on dry/necrotic wounds or those with minimal exudate. Low-adherent versions are available for patients with fragile skin. | • Curaplon® (Dynarex Corporation, Orangeburg, Florida)  
• Optifoam® (Medline Industries, Inc., Romulus, Michigan)  
• Allevyn® (Smith & Nephew, Watford, United Kingdom)  
• McKesson™ Foam Dressing (McKesson Corporation, Irving, Texas) |
| Films            | Allows for visualization of wounds during healing. Provides bacterial protection. Adheres to wounds in mobile areas. | Use as primary dressing over superficial dry- or low-exuding wounds. Can be used as secondary dressing over alginates or hydrogels for rehydration of wound bed. | Do not use on patients with fragile or compromised periwound skin, skin sensitive to adhesive, or infected wounds. | • Hydrofilm® (Hartmann USA, Inc., Rock Hill, South Carolina)  
• Suprasorb® F (Lohmann & Rauscher, Milwaukee, Wisconsin)  
• Kendall™ Transparent Film (Cardinal Health, Inc., Dublin, Ohio) |
| Biologic Dressings | Provides scaffolding and support to wounds. Moisturizes and regulates wound bed. Stimulates host cells. | Use on dry to high exudative wounds. Can cover open wounds. | Do not use with known allergy to source material. Very low risk of cross infection from the dressing source. | • Puracol® (Medline Industries, Romulus, Michigan)  
• Skin Temp II™ (Human Biosciences Inc., Gaithersburg, Maryland)  
• Biopad® (SkinSafe LLC, Phoenix, Arizona) |
| Composite Dressings | Absorbs and maintains moisture. Bacterial protection. Semi-adhesive form for use on mobile wound sites and non-adhesive for optimal wound healing. | Use on superficial, light to moderately exudative wounds. | Do not use semi-adhesive form if patient is sensitive to adhesives. May dry out wound bed if used on dry or very lightly exudative wounds. | • Alldres® (Molnycke Health Care, Indianapolis, Indiana)  
• DynaGuard™ (Dynarex Corporation, Orangeburg, New York)  
• Multi Layered Composite Dressing (MPM Medical Inc., Irving, Texas)  
• Cardinal Health™ Composite Dressing (Cardinal Health, Inc., Dublin, Ohio) |
In the next section, we discuss the features and benefits of several types of wound dressings listed on Table II.

Table II
Properties of dressing materials and topical agents

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| Silver         | Antimicrobial action                         | Use on wounds with clinical signs of infection. May be used on wounds of all exudate levels. Can be combined with many other dressings. | Do not use if known sensitivity to silver. Reevaluate after use to ensure proper antimicrobial coverage. | Silvercel™ (Acelity L.P. Inc., San Antonio, Texas)
|                |                                              |                                                     |                              | Biatin® Silicone Ag Foam Dressings (Coloplast Corporation, Minneapolis, Minnesota) |
|                |                                              |                                                     |                              | DermaGinate™ Ag Alginate Dressing with Antibacterial Silver (DermaRite Industries LLC, North Bergen, New Jersey) |
| Iodine         | Antimicrobial action                         | Use on wounds with clinical signs of infection. May be used on wounds of all exudate levels. Can be combined with many other dressings. | Do not use if known sensitivity to iodine. Do not use if tissue is dry and necrotic. Use temporarily to prevent systemic absorption. | Iodoflex® (Smith & Nephew, Watford, United Kingdom)
|                |                                              |                                                     |                              | IodoFoam® (Progressive Wound Care Technologies, Savannah, Georgia) |
| PMD            | Cleanses wounds and breaks down wound debris. Stimulates blood flow to wound. Balances moisture. Reduces pain and edema. | Use on dry and exudative wounds of all levels. Use for venous, diabetic, or pressure ulcers of all stages. Indicated for chronic wounds and infected wounds. | May require multiple dressing changes for high exudative wounds. May generate more exudate production. | Polymem® (Ferris Mfg Corp., Fort Worth, Texas) |
| Protease modulating | Actively or passively controls protease enzyme levels in wound bed. Modulates collagen breakdown to prevent sloughing. | Cleanses wounds that are not progressing despite correction of underlying causes, exclusion of infection, and optimal wound care. | Do not use on dry wounds or those with leathery eschar. | PROMOGRAN™ (Acelity L.P. Inc., San Antonio, Texas) |

In the next section, we discuss the features and benefits of several types of wound dressings listed on Table II.

### TYPES OF WOUND DRESSING

**Gauze**

Gauze is one of the oldest and most commonly used dressings, but it does not accomplish the goals of a good dressing when used as a primary dressing. Gauze dries the wound surface rapidly and is permeable to bacteria. It is also adherent and may traumatize the wound upon removal. For these reasons, gauze is most useful for immediate or short-term application and not for long-term management. As a cost-effective dressing, gauze comes in synthetic or cotton forms, with different pore sizes and fiber density available to increase functionality. The synthetic form is more absorptive; however, both types of gauze still allow for bacterial invasion into pores as well as granulation tissue adherence.

Impregnating gauze involves saturating a gauze with petrolatum, bismuth, zinc, or other compounds. This allows for the surface to become less adherent. Impregnated gauze can be used in adjunct with other dressings to supplement occlusiveness or provide moisture to a drying wound bed. Gauze dressings are versatile, easy to change, and can be used on both non-infected and infected wounds of any shape and size. Considerations when using gauze include the possible reinjury from dressing changes, if adherence has occurred, or the chance of leaving residue behind which may lead to the formation of a granuloma.

**Hydrocolloids**

Hydrocolloids, like hydrogels, are moisturizing dressings best used on dry wounds. They come in two forms: sheet and gel. The sheet form has an external semi-permeable membrane permitting gas exchange and an internal layer with hydrophilic compounds in a hydrophobic suspension designed to balance moisture. They differ from hydrogels in that they are made from larger compounds, such as carboxymethylcellulose, gelatin, and pectins. These compounds may potentially cause contact wounds of any thickness. They are also useful on eschars as they keep the eschar soft, allowing for a better environment to clear necrotic debris. They provide a non-adherent contact surface that has been shown to reduce pain, provide a cooling sensation, and prevent tensile or frictional trauma to the wound bed. However, they should not be used on infected or heavily draining wounds due to their poor absorption.

**Hydrogels**

Hydrogels are water- or glycerin-based dressings best indicated for dry wounds as they donate moisture to the wound bed. They can be used on dry and mild or moderate draining wounds of any thickness. They are also useful on eschars as they keep the eschar soft, allowing for a better environment to clear necrotic debris. They provide a non-adherent contact surface that has been shown to reduce pain, provide a cooling sensation, and prevent tensile or frictional trauma to the wound bed. However, they should not be used on infected or heavily draining wounds due to their poor absorption.
exudate buildup on the lateral edges of wounds, both infected and non-infected dressing choices for use on exudative wounds. Alginates are polysaccharide com-
pounds derived from algae or kelp. Calcium in the dressing reacts with sodium in the exudate to produce a soluble sodium-calcium gel on contact, which holds and balances moisture around the wound bed. Alginates can absorb over 20 times their weight in fluid, making them useful for heavily exudative wounds of partial or full thickness. The calcium in the dressing can also activate platelets promoting hemostasis of the wound bed. Usage on dry or low exudative wounds is not advised as the removal of the dressing may be difficult and cause pain. Hydrofibers are not made from the same material as alginites but from carboxymethylcellulose fibers. They are functionally similar to alginites with the ability to hold even more fluid. Like hydrocolloids, alginites and hydrofibers can be left over a wound for several days without changing. This is due to the inner layer which holds and maintains fluid within, preventing desiccation. Less frequent dressing changes improves the cost-effectiveness of the dressing and reduces wound trauma that may stem from frequent changes. Hydrocolloids can be used on abrasions, superficial pressure ulcers, surgical wounds, graft sites, and burns. Patients should be warned about “gel and smell”, a malodorous yellow development underneath the dressing that can be mistaken for infection but is benign. 13

Alginates and hydrofibers

Alginates and hydrofibers are great dressing choices for use on exudative wounds, both infected and non-infected. Alginites are polysaccharide compounds derived from algae or kelp. Calcium in the dressing reacts with sodium in the exudate to produce a soluble sodium-calcium gel on contact, which holds and balances moisture around the wound bed. Alginites can absorb over 20 times their weight in fluid, making them useful for heavily exudative wounds of partial or full thickness. The calcium in the dressing can also activate platelets promoting hemostasis of the wound bed. Usage on dry or low exudative wounds is not advised as the removal of the dressing may be difficult and cause pain. Hydrofibers are not made from the same material as alginites but from carboxymethylcellulose fibers. They are functionally similar to alginites with the ability to hold even more fluid. Like hydrocolloids, alginites and hydrofibers can be left over a wound for several days without changing. This is due to the inner layer which holds and maintains fluid within, preventing desiccation. Less frequent dressing changes improves the cost-effectiveness of the dressing and reduces wound trauma that may stem from frequent changes. Hydrocolloids can be used on abrasions, superficial pressure ulcers, surgical wounds, graft sites, and burns. Patients should be warned about “gel and smell”, a malodorous yellow development underneath the dressing that can be mistaken for infection but is benign. 13

Foams

Foams are one of the most popular and used dressing type due to their versatility, easy application, and cost-effectiveness. Most foam dressings have three layers, allowing them to accomplish numerous ideal dressing criteria: a hydrophobic semi-permeable outer layer blocks bacteria and allows for gas exchange, an absorptive middle layer retains fluid, and a porous, hydrophilic inner layer draws fluid from the wound bed into the middle layer but is small enough to prevent granulation tissue adherence as with gauze. The soft material protects the wound bed from trauma, and the non-adherent inner layer allows for convenient dressing changes. Foam rapidly absorbs fluid from wounds, versus alginites which take more time. This prevents excessive fluid accumulation at the wound borders as seen in alginites/hydrofibers, which could damage nearby skin and delay wound healing. However, due to their rapid absorption, foams require more frequent dressing changes than alginites and hydrofibers. They are not commonly advised for an excessive exudative wound due to their limited capacity, nor are they recommended for dry wounds or eschars, as they are too drying. They are most ideal on non-infected or infected granulating wounds, surgical wounds, and graft donor sites with moderate to heavy exudate.

Films

Films are clear, thin, semi-permeable sheets of polyurethane that are efficient at permitting gas exchange and preventing bacterial colonization or wound contamination. 13 They are useful for visualizing the wound as it heals, but do not offer much in terms of absorption or moisture. Because they lack absorption, fluid can accumulate underneath the dressing, requiring frequent dressing changes. The adhesive nature of the dressing can also retraumatize a wound upon removal. Films are ideal for superficial wounds, generally just affecting the epidermis, that are non- or mildly-exudative. 13 Caution should be advised for wounds on patients with fragile skin or on those who may be sensitive to the adhesive. Films are not recommended for infected wounds because of their limited absorptive capacity.

Biologic dressings

Biologic cell-based dressings are designed from allogenic, synthetic, or xenogeneic sources including skin, placenta, amnion, fascia, or intestinal lining. They are intended to provide a wound with a natural source of colla-
deoxyribonucleic acid/ribonucleic acid (DNA/RNA) damage, disrupting the mitochondria, and competing with essential metals to reduce the function of key bacterial enzymes. Due to silver’s mechanism of action and broad spectrum of antimicrobial activity, it can be used on heavily-infected wounds and even against drug-resistant bacteria. It can also be used alongside debridement and/or systemic antibiotics. A downside to silver is that it may be cytotoxic to host fibroblasts and delay wound healing, despite lowering the bioburden of a wound. Thus, it is not recommended for routine infection prophylaxis. Silver may also not be effective on necrotic tissue or on wounds with biofilms, and its antimicrobial properties may be inactivated by saline as the sodium-chloride interferes with the silver ions. It used to be believed that silver dressings should be removed before magnetic resonance imaging (MRIs), but new research has demonstrated that it is safe to leave these dressings on.

Iodine is now accepted as the broadest-covering antimicrobial agent, active against most types of bacteria, viruses, fungi, spores, and protozoa. It comes in various forms, such as cadexomer-iodine or povidone-iodine, with the free iodine unbinding from these compounds acting as the antimicrobial agent. Compared to silver, studies have demonstrated iodine to be less cytotoxic to host cells involved in wound healing, making it a better choice for infection prophylaxis. Iodine dressings are also more cost-effective than silver dressings. Long-term use, however, can temporarily stain tissues underneath the dressing. It may also, at rare times, be absorbed in sensitive individuals and lead to systemic effects such as thyroid dysfunction.

Topical antiseptics can be applied to a dressing and placed directly on a wound bed. These include hydrogen peroxide, diluted bleach in water with or without boric acid (termed Dakins and eusol solution), or diluted acetic acid (vinegar and water). These dressings should not be left on for long, as they can also damage normal host tissue due to their chemical nature, thus requiring frequent changes. A dressing can also be covered in a topical antibiotic such as mupirocin. Topical antibiotics can also provide moisture. However, emerging bacterial resistance to mupirocin has been reported.

Polymer membrane dressings
Polymer membrane dressings (PMD) are a relatively new and extremely versatile type of dressing that can be used on non-infected or infected wounds with all amounts of exudate (dry to heavy). They resemble a foam dressing with multiple layers. The inner layer contains a moisturizer to support dry wounds and prevent desiccation. The inner layer also contains a wound-cleansing surfactant that helps breakdown and absorb debris and prevents granuloma formation and infection. The middle layer collects fluid and the backbone is semi-permeable, allowing for gas exchange. PMDs have been indicated for controlling pain at the wound site as they have been noted to interact with nocireceptors. They have also been found to decrease edema and odor and improve wound nutrient supply. This is all accomplished due to the elastic, suctioning nature of the dressing, which creates flow and pulls fluid from the wound bed into the dressing. This flow draws fresh blood from capillaries, moisturizing the wound bed and preventing fluid stasis. Unlike foams, PMDs can be used on dry wounds due to their moisturizing inner layer. There may be an initial increase in exudate production from the wound bed due to the suctioning nature of the dressing.

Other dressings
Protease-lowering dressings promote wound healing by counteracting the increased levels of proteases that have been linked in studies to chronic wound development. It is believed that bacterial colonization, along with cellular damage due to repetitive ischemia and reperfusion, all lead to increased
cytokines by host immune cells that increase protease levels in the wound bed and lead to local destruction and sloughing of a wound. A phosphorylated cotton dressing has been developed that is designed to capture and absorb proteases by binding the negative phosphate groups to the positively charged amino acid sidechains of proteases. This dressing leads to increased slough removal and promotes granulation and wound healing.

Dressings with proteolytic enzyme preparations have been developed that can break down collagen and can also assist in debridement. These dressings promote collagen cycling, which can help stimulate a chronic wound into normal healing. Nonviable collagen will be digested faster than viable collagen, allowing for a healthier scaffolding to remain in the wound bed as the nonviable collagen is replaced.\(^\text{15}\)

**CHOICE OF WOUND DRESSING**

The choice of dressing should be decided based on the wound properties: acute or chronic, infected or non-infected, draining or non-draining, plus the depth and shape of the wound (Figs. 1–5). It can also be dictated based on a physician’s experience, accessibility in the moment, and cost. General dressing choices for various types of wounds are listed on Table III.

It is also important to take patient compliance into consideration. Factors, such as the cost, ease of dressing changes, frequency of changes, and need for additional antibiotics, should influence clinical decision making.

In addition to the guiding principles of moisturizing a dry wound and absorbing moisture from a highly exudative wound, a healthcare provider should use his best judgement in each scenario to guide dressing selection. For instance, wounds on mobile areas require an adhesive dressing, but an adhesive dressing should not be used on fragile skin. Dressings with absorptive qualities may increase exudate production. Certain dressings lead to discoloration or odor formation, such as with hydrogels, whereas others, such as PMDs, help combat odor.

One should monitor the wound throughout the healing process, observing for any known complications of dressings, such as lateral wicking with alginates or exudate buildup with films. Dressings should be switched if wound healing is not progressing correctly in a timely manner or if the wound is getting worse.

### Table III

<table>
<thead>
<tr>
<th>Type of Wound</th>
<th>Dressing Choice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superficial Wounds</td>
<td>Films, Hydrocolloids, PMDs</td>
</tr>
<tr>
<td>Eschar Wounds</td>
<td>Hydrogels, Hydrocolloids, PMDs</td>
</tr>
<tr>
<td>Exudative Wounds</td>
<td>Alginates, Hydrofibers, Foams, PMDs</td>
</tr>
<tr>
<td>Granulating Wounds</td>
<td>Hydrocolloids, Foams, PMDs</td>
</tr>
<tr>
<td>Sloughing Wounds</td>
<td>Protease-lowering or enzymatic dressings, Hydrogels, Hydrocolloids</td>
</tr>
<tr>
<td>Deep/Tunneling Wounds</td>
<td>Alginates, Hydrofibers, Hydrogels, PMDs</td>
</tr>
<tr>
<td>Infected Wounds</td>
<td>Silver, Iodide, Antibiotic Dressings, PMDs</td>
</tr>
</tbody>
</table>

**CONCLUSION**

Despite the constant developments, the general principles of wound dressing are timeless. The choice of dressing depends on the anatomical and pathophysiological characteristics of the wound. A thorough understanding of the indications and contraindications for the various dressings is a valuable toolbox for any practitioner and will assist
patients in recovering from wounds faster, prevent infection, minimize pain and scarring, and enhance overall patient outcomes.

AUTHORS’ DISCLOSURES

The authors have no conflicts of interest to disclose.

REFERENCES


