The needs of wounds differ as they progress through the healing process, and all wounds benefit from a properly moist environment that supports normal cell function. With just a few different moisture-retentive dressings (MRDs), the clinician can work synergistically with the cells to support microscopically precise debridement and repair for a wide variety of wounds, while providing the patient with a faster, healthier, and more comfortable healing experience.

WOUND DEBRIDEMENT
The first step of wound care, whether from the viewpoint of white blood cells (WBCs) or the clinician, is debridement—that is, removing all contaminants, such as foreign material and bacteria, and damaged tissue from the wound.1

Debridement can be:
• **Selective**: Removal of unhealthy tissue while healthy tissue is spared
• **Nonselective**: Removal of both healthy and unhealthy tissues.

Forms of debridement include:
• **Autolytic debridement**: Performed by WBCs during the first 3 to 5 days after the wound occurs (inflammatory/debridement phase) (Figures 1 to 4). This form of debridement is the most selective because it spares healthy cells and intact matrix molecules while removing damaged cells and matrix with microscopic precision.2
• **Surgical debridement**: Tissue removed by surgeon according to characteristics, such as color, texture, vascular supply, and temperature; selective on a macroscopic level.
• **Mechanical debridement**: Physical removal of tissue adhered to a dried-on dressing; nonselective and, thus, the least desirable form of debridement.

FIGURE 1. Several days after being hit and pinned under a car, this mixed-breed dog developed an eschar on its left side that ultimately sloughed, leaving a large wound. Surgical intervention was limited due to the client’s financial restrictions. Because this dog was treated before my exposure to moist wound healing practices, healing time was long. The boxed area shows the location of the wound.

FIGURE 2. Patient from Figure 1; day 7 after injury: Necrotic tissue and an eschar (asterisk) remain after a large section of skin had sloughed. Microscopically, WBCs are selectively debriding the diseased tissue. Surgical debridement and lavage were performed after this photograph was taken.
WOUND CLOSURE
Wound closure is performed after all contaminants and nonviable tissue have been removed, and it can be orchestrated by the animal’s body or clinician.

Physiology of Wound Closure
The body typically accomplishes closure over 2 to 4 weeks via the repair (proliferative) phase of wound healing. During this phase, skin coverage of the wound is achieved through 2 simultaneous, yet independent, means—epithelialization and contraction.

This process is accomplished by creation of:
• Granulation tissue: As wound bed debridement by WBCs progresses, cells on the periphery of the wound receive signals to move in and fill the cleaned-out defect with granulation tissue. Granulation tissue is built by fibroblasts, which secrete new extracellular matrix molecules (eg, collagen, elastin) and endothelial cells, which build new blood vessels (Figures 2 and 3).
• Epidermis: Epithelial cells on the skin edge then migrate onto the granulation tissue, which provides the oxygen, moisture, and surface required for epithelial cells to proliferate, cross the wound, and create a new epidermis (Figure 4).
• Myofibroblasts: Wound contraction occurs when the fibroblasts that formed the granulation tissue meet in the center of the wound and develop characteristics similar to smooth muscle. Now called myofibroblasts, these cells—linked to each other by intercellular connections and to the wound edges via their attachments to the granulation tissue—contract and exert centripetal force on the skin edges, drawing them toward the center of the wound (Figure 4).

Wound fluid, a derivation of plasma that leaks out of blood vessels due to increased capillary permeability in response to inflammation, contains many beneficial factors for healing, including oxygen, nutrients, cytokines, growth factors, chemotactic factors, WBCs, enzymes that aid selective debridement, and systemic antibiotics, if the animal is receiving them. Wound fluid is serousanguineous in appearance.

Exudate, which has a more cloudy appearance, consists of wound fluid plus liquefied necrotic tissue created by WBCs via autolytic debridement and edema caused by inflammation, decreased patient mobility, and inadequate lymphatic or venous drainage. Exudate levels are proportionate to the amount of contamination, infection, and tissue damage in a wound, and should subside as the wound transitions from the inflammatory/debridement phase to the repair phase.

Persistant exudate is an indication that more aggressive surgical debridement may be needed to remove foreign material, sites of infection, and/or nonviable tissues.

Surgical Closure of Wounds
Surgical closure can be:
• Primary: Immediate
• Delayed primary: Before granulation tissue formation
• Secondary: After granulation tissue formation.

Surgical closure should be reserved for wounds that contain only viable tissue, are free of contamination, and can be closed in a tension-free manner.

Regardless of timing, surgical closure is preceded by one or more rounds of debridement and lavage, and, except in the case of primary closure, initial management as an open wound.

Gradation of Wound Effusion
Wound fluid, a derivation of plasma that leaks out of blood vessels due to increased capillary permeability in response to inflammation, contains many beneficial factors for healing, including oxygen, nutrients, cytokines, growth factors, chemotactic factors, WBCs, enzymes that aid selective debridement, and systemic antibiotics, if the animal is receiving them. Wound fluid is serousanguineous in appearance.

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Persistant exudate is an indication that more aggressive surgical debridement may be needed to remove foreign material, sites of infection, and/or nonviable tissues.
Moist Wound Healing (MWH) is now the standard of care.

**OPEN WOUND MANAGEMENT**

Open wound management includes covering the wound with an appropriate dressing and bandage; it does not mean the wound is left open to the environment. The goal of open wound management is to work synergistically with the cells, providing the best environment possible to support the body’s wound healing process.

In some cases, open wound management may be continued until the wound closes on its own (second intention healing); this is appropriate when:

- Healing is progressing well
- Reconstructive surgery is not needed to prevent contracture or scarring that might inhibit mobility or be cosmetically unacceptable
- The patient tolerates bandaging.

**Wet-to-Dry Bandages**

Wet-to-dry bandages involve placing saline-soaked gauze pads on the wound, then removing them after the bandages have dried and adhered to the wound. Although once a traditional choice in human and veterinary medicine, wet-to-dry bandages are no longer the standard of care because they compromise wound healing in many ways (Table 1).

**MOISTURE-RETENTIVE DRESSINGS**

- Allow healing to progress 24 hours a day because wound does not dry out
- Remove excess exudate
- Maintain contact between wound fluid and wound, allowing patient to benefit from normal balance of prohealing factors during each healing phase
- Promote optimal function of cells and proteases, which orchestrate healing
- Stimulate faster healing with lower infection rates
- Require less frequent bandage changes and are more comfortable during, and in between, bandage changes
- Eliminate disadvantages of wet-to-dry bandages
- Decrease costs for total wound care

---

**TABLE 1.**

<table>
<thead>
<tr>
<th>WET-TO-DRY BANDAGES</th>
<th>MOISTURE-RETENTIVE DRESSINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Macerate (overhydrate); then desiccate wound bed, compromising function of cells involved in wound healing</td>
<td>• Allow healing to progress 24 hours a day because wound does not dry out</td>
</tr>
<tr>
<td>• When removed, much-needed cells and tissue, such as WBCs, granulation tissue, and new epithelium, along with necrotic tissue, are pulled off (nonselective mechanical debridement)</td>
<td>• Remove excess exudate</td>
</tr>
<tr>
<td>• WBCs migrate into the open-weave dressing</td>
<td>• Maintain contact between wound fluid and wound, allowing patient to benefit from normal balance of prohealing factors during each healing phase</td>
</tr>
<tr>
<td>• Environmental bacteria can penetrate gauze</td>
<td>• Promote optimal function of cells and proteases, which orchestrate healing</td>
</tr>
<tr>
<td>• Cause discomfort when worn and when removed</td>
<td>• Stimulate faster healing with lower infection rates</td>
</tr>
<tr>
<td>• Remnants of gauze fiber remain in the wound, resulting in inflammation</td>
<td>• Require less frequent bandage changes and are more comfortable during, and in between, bandage changes</td>
</tr>
<tr>
<td>• Increase costs for total wound care</td>
<td>• Eliminate disadvantages of wet-to-dry bandages</td>
</tr>
</tbody>
</table>

---

**Types of MRDs**

Many MRDs are available (Table 2). In my experience, the clinician can manage most companion
animal wounds by focusing on the following 4 types (in order from most absorptive to least absorptive):
1. Calcium alginate
2. Polyurethane foam
3. Hydrocolloid
4. Hydrogel.

Table 3 (page 36) summarizes the characteristics and indications for each of these dressings.

Selection of MRDs
To select the most appropriate MRD, the clinician must ask:
• How much exudate do I expect this wound to produce?
• What does this wound need (eg, debridement or granulation)?

Table 4 (page 37) provides guidelines for selecting a dressing based on the answers to these 2 questions. Examples of appropriate dressing selection and application in veterinary patients are provided by Figures 5 to 16 (pages 35 to 41).

APPLICATION OF MRDS
MRDs are typically applied after surgical debridement and lavage. However, in a compromised patient in which anesthesia and surgical debridement are not possible, MWH provides a safe means of getting wound debridement underway until the patient is more stable.

TABLE 2.
Examples of Companies That Carry a Line of MRDs

<table>
<thead>
<tr>
<th>Company</th>
<th>Website</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covidien Animal Health</td>
<td>covidien.com/animalhealth</td>
</tr>
<tr>
<td>Kruuse</td>
<td>kruuse.com</td>
</tr>
<tr>
<td>Jazz Medical</td>
<td>jazzmed.com</td>
</tr>
<tr>
<td>Derma Sciences</td>
<td>dermasciences.com/medihoney</td>
</tr>
</tbody>
</table>

Fitting the Dressing
As for any wound, use aseptic technique when handling the MRD and tissue. MRDs retain moisture in the wound. To avoid maceration (overhydration) of the skin and subsequent compromise of its epithelial barrier function, ensure the dressing is in contact with the wound surface but not with the skin (Figures 5, 6, and 10 to 12, page 38).

• To help achieve the right fit, press the dressing on the wound and cut along the resulting imprint (Figure 11, page 38).
• When fitting the dressing to the wound, consider the wound’s depth and contour:
  » Dressings that absorb and retain a lot of exudate, such as calcium alginate and

FIGURE 5. A German shorthaired pointer dog with multiple maggot-infested bite wounds. The appearance of this right lateral wound near the stifle was typical of this dog’s wounds. After the dog was anesthetized, wounds were lavaged and debrided of clearly nonviable tissue and maggots. Sutures were placed around the wound to secure a tie-over bandage.

FIGURE 6. Patient from Figure 5: Calcium alginate was placed in the wounds to absorb the anticipated high level of exudate and support ongoing autolytic debridement by WBCs.
polyurethane foam, increase in size.

» Dressings that begin as a gel, or interact with wound fluid to become a gel, conform well to the nooks and crannies of an irregular wound surface (Figures 7 and 8).

» Some MRDs have adhesive borders designed to adhere to the periwound skin and protect it from moisture (Figure 16, page 41).

Adding a Semipermeable Cover
When a semipermeable cover is not built into the MRD, adding an adhesive transparent polyurethane film over the MRD can be desirable in some cases (Figure 16). The semipermeable film allows gas exchange but serves as a barrier to bacteria and moisture. Thus, the film:7,9

- Helps protect wound from exogenous organisms
- Keeps wound fluid in and environmental fluid out of the wound
- Helps hold the MRD in place.

Because the film is waterproof and has no absorptive capability of its own, it prevents wicking of excess exudate into the cast padding. Therefore, it should not be used in situations in which the

**TABLE 3. Characteristics of Common MRDs**

<table>
<thead>
<tr>
<th>MRD</th>
<th>EXUDATE LEVEL</th>
<th>PROPERTIES</th>
<th>INDICATIONS</th>
<th>CONTRAINDICATIONS/ PRECAUTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium alginate</td>
<td>High; calcium alginate absorbs 20–30× its weight in fluid</td>
<td>• Made from seaweed&lt;br&gt; • Felt-like material that turns to gel as it absorbs wound fluid&lt;br&gt; • Ca+2 stimulates macrophage and fibroblast activity, promotes hemostasis&lt;br&gt; • Gel entraps bacteria</td>
<td>• Especially good for autolytic debridement of contaminated, moderate to highly exudative wounds&lt;br&gt; • Good stimulator of granulation tissue&lt;br&gt; • Need for hemostasis in oozing wounds</td>
<td>• If exudate insufficient, product does not gel and dehydrates wound</td>
</tr>
<tr>
<td>Polyurethane foam</td>
<td>Moderate to high</td>
<td>• Soft foam&lt;br&gt; • Does not gel, but helps keep proper moisture level in contact with wound surface&lt;br&gt; • Some have adhesive border</td>
<td>• Particularly good for supporting epithelialization&lt;br&gt; • Supports autolytic debridement and granulation&lt;br&gt; • Can wick moisture out of macerated skin&lt;br&gt; • Premoisten with saline to use on wound with lower exudate level</td>
<td>• If exudate is insufficient, wound dehydrates (unless foam is premoistened with saline)&lt;br&gt; • Foam too soft to protect bony prominences</td>
</tr>
<tr>
<td>Hydrocolloid</td>
<td>Low to moderate</td>
<td>• Sheet, paste, or powdered forms&lt;br&gt; • All turn into a gel as wound fluid is absorbed&lt;br&gt; • Sheets typically have occlusive backing/adhesive perimeter to attach to periwound skin&lt;br&gt; • Gel entraps bacteria</td>
<td>• Good for autolytic debridement, granulation, and epithelialization&lt;br&gt; • Hydrocolloid sheet with impermeable backing can be used to add occlusive cover over other dressings&lt;br&gt; • Use caution if infection is present because occlusive backing creates hypoxic environment that can favor anaerobes</td>
<td></td>
</tr>
<tr>
<td>Hydrogel</td>
<td>Low to none</td>
<td>• Up to 95% water&lt;br&gt; • Comes as gel or sheet that turns to gel in wound&lt;br&gt; • Add polyurethane film cover (if not built into hydrogel sheet) to keep hydrogel’s moisture in wound</td>
<td>• Dry wounds requiring autolytic debridement, granulation, or epithelialization&lt;br&gt; • May enhance contraction on limb wounds&lt;br&gt; • Cooling effect may decrease pain&lt;br&gt; • Maceration can result if exudate overwhelms hydrogel’s low absorptive capacity</td>
<td></td>
</tr>
</tbody>
</table>

*Data obtained from references 4,6,7,9,12,14,16–19*
underlying MRD cannot absorb and retain all of the wound’s exudate.

Bandaging the Wound

After placement of the MRD, bandage the wound in the standard fashion with:

- **Cast padding:** To keep the dressing in contact with the wound, absorb excess moisture, and provide protection
- **Conforming gauze roll:** To stabilize the cast padding
- **Outer layer:** Surgical tape or a cohesive (self-adherent) wrap, to provide pressure appropriate to the injury and keep inner layers clean.15

### CHANGING THE MRD

The frequency of bandage changes depends on:
1. Amount of exudate produced
2. How well the exudate is being addressed by the MRD.

The dressing should be changed before it becomes **oversaturated** or **dries out**.

- Lift gel out if coherent (Figure 8), or gently lavage the gel out if not.
- If the MRD has dried out and is stuck to the wound, inject sterile saline at the dressing/wound interface to release the dressing and avoid a wet-to-dry effect.

Adherence of the dressing may signal that the chosen dressing was:
1. Too absorptive for the given exudate level
2. Left in place too long.

In either case, a different dressing should be

### TABLE 4. Guidelines for Dressing Selection Based on Exudate Level & Wound Needs

<table>
<thead>
<tr>
<th>EXUDATE LEVEL</th>
<th>Wound Requires DEBRIDEMENT OR GRANULATION</th>
<th>Wound Requires EPITHELIALIZATION &amp; CONTRACTION*</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Calcium alginate</td>
<td>Not applicable; high exudate very unlikely at this phase</td>
</tr>
<tr>
<td>Moderately high</td>
<td>Polyurethane foam</td>
<td>Polyurethane foam</td>
</tr>
<tr>
<td>Moderate</td>
<td>Hydrocolloid</td>
<td>Hydrocolloid</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Saline-moistened polyurethane foam†</td>
</tr>
<tr>
<td>Moderately low</td>
<td>Hydrocolloid</td>
<td>Saline-moistened polyurethane foam†</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hydrogel</td>
</tr>
<tr>
<td>Low to minimal</td>
<td>Hydrogel</td>
<td>Saline-near-saturated polyurethane foam†</td>
</tr>
</tbody>
</table>

* Dressings with adhesive borders may slow contraction when used in the later part of the repair phase.19
† Polyurethane foam supports epithelialization and contraction, but its strong absorptive capacity may dry out a wound with low exudate. In such cases, polyurethane foam can be premoistened with saline.
selected for the replacement bandage.

Indeed, the dressing selected at the beginning of wound management is likely to be different from the dressing selected later in wound healing because exudate level and needs of the wound change over time.

- During the inflammatory phase of healing, when exudate production is highest, a properly chosen MRD is typically changed every 2 to 3 days.
- As granulation tissue forms, a less absorptive dressing is usually appropriate, and the interval between bandage changes may be increased up to 7 days.
- A bandage change should always be performed if strike-through or soiling occurs, regardless of the time since the dressing was placed.

MAKING THE CHANGE TO MWH

The use of MRDs and MWH requires some adjustments for clinicians more familiar with dry or wet-to-dry dressings.

Qualities of Gel

Many MRDs combine with wound fluid to form a gel, and it is normal for this gel to have a slight odor, yellowish tinge, and slimy feel. While these...
characteristics can give the impression of infection, they are normal properties of these gels (Figure 8).

The wound and patient should always be examined for signs of infection, such as redness, swelling, pain, purulent discharge, and fever. In the absence of such signs, the bandage change can proceed as planned. If infection is present, MWH should still be used to support WBC function, with the dressing choice adjusted, if needed, to handle a higher exudate level.

**Timing of Dressing Changes**

The clinician new to MWH may initially feel uncomfortable waiting multiple days between bandage changes. One way to handle this concern is to, using aseptic technique, unwrap the bandage and look at the dressing in the wound. Upon noting, for example, that a calcium alginate or polyurethane foam dressing is not yet saturated, or that a hydrogel is still moist, the dressing is left in place and bandage replaced. After examining dressings for a few patients, the clinician becomes familiar with the behavior of MRDs and comfortable with the longer intervals between bandage changes.

**Increased Cost of MWH**

Some clinicians may hesitate to use MRDs because the dressings themselves cost more than gauze or other dry dressings. However, the most cost effective dressing is the one that results in lowest overall cost of care. The overall cost of treating a wound with MRDs is lower than with traditional wet-to-dry or dry dressings for several reasons, including faster healing time, less frequent bandage changes (and, thus, lower material and labor costs), and less need for sedation during bandage changes.

MRD = moisture-retentive dressing; MWH = moist wound healing; WBC = white blood cell

**FIGURE 13.** Nonhealing axillary wound—that had dehisced after each of several attempts at closure—in a cat. Prior to this image, the wound had no granulation tissue and a moderately high exudate level; thus, it was bandaged with a polyurethane foam dressing. At the time of this image, the wound required additional granulation tissue and epithelialization. Because the exudate level had decreased to a moderately low level, a polyurethane foam dressing—premoistened with saline before application—was used. The wound healed without requiring surgery.

**FIGURE 14.** Wound on the medial tarsus of a dog’s limb that is producing a moderate level of exudate; granulation tissue is present but the wound requires epithelialization. Hydrocolloid or saline-moistened polyurethane foam are appropriate dressing choices.

**FIGURE 15.** Degloving wound—that has been lavaged and debrided—on distal limb of border collie dog; residual moisture from the lavage can be seen. Due to the wound’s dry nature, a hydrogel dressing was selected.
MOIST WOUND HEALING: THE NEW STANDARD OF CARE

FIGURE 16. Dry, chronic wound on the tarsus of an 8-year-old Labrador retriever; hydrogel-impregnated gauze was placed after debridement (A). Following placement of a Telfa pad (covidien.com) over the hydrogel gauze, a polyurethane film was placed on top to secure the primary and secondary dressings and help maintain moisture in the wound (B and C).

References