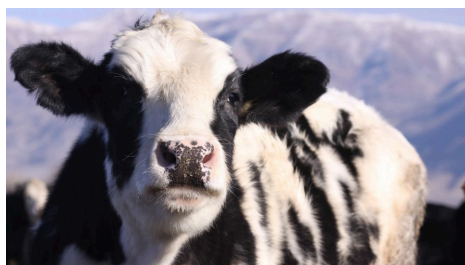


Digital Dermatitis, Sole Ulcers, and White Line Disease in Dairy Cattle: Pathogens, Diagnosis, and Treatment

07/23/2026



Key Takeaways

1. Hoof lesions are the leading cause of lameness in dairy cows.
2. Digital dermatitis, sole ulcers, and white line disease are the most common and impactful hoof lesions in North American dairy herds.
3. Each hoof lesion has a distinct cause and risk profile, meaning prevention and treatment strategies are not one-size-fits-all.
4. Each lesion develops differently and requires a specific prevention and treatment approach.
5. Early detection and treatment improve recovery and help limit disease progression.
6. Prevention focuses on hygiene, cow comfort, hoof trimming, and reducing stress on the hoof.

This fact sheet focuses on three common hoof lesions in dairy cattle: digital dermatitis, sole ulcers, and white line disease, and describes how differences in pathogenesis and risk factors influence diagnosis, prevention, and treatment.

Why Talk About Hoof Lesions?

Lameness, defined as impaired locomotion, is closely linked to hoof lesions, although it can arise from multiple conditions, including trauma, arthritis, muscle or tendon injuries, and neurologic disease (Cramer et al., 2024). Most lame cows have underlying hoof lesions; however, not all cows with hoof lesions are visibly lame, particularly

when lesions are mild or in early stages (van Huyssteen et al., 2020).

In North American dairy herds, the most common hoof lesions include digital dermatitis, sole ulcers, and white line disease (Cramer et al., 2008; DeFrain et al., 2013; Solano et al., 2016). Lameness cases are associated with reduced milk production (Puerto et al., 2021), impaired reproduction (Mellado et al., 2018), and a higher risk of culling (Ózsvári, 2017; Puerto et al., 2021), highlighting the value of prevention and treatment.

For a broader overview of lameness and how to recognize it on your farm, see these USU Extension fact sheet [“Lameness in Dairy Cattle: A Practical Overview.”](#)

For a more practical, producer-focused overview of these lesions, see USU Extension’s [“Three Common Hoof Problems in Dairy Cows: What to Watch For and How to Prevent Them.”](#)

Figure 1. Active Digital



Dermatitis

Digital Dermatitis

Characterization

Digital dermatitis, also known by various names including strawberry foot rot, foot warts, hairy heel warts, raspberry heel, verrucose dermatitis, Mortellaro's disease, and papillomatous digital dermatitis, is the most commonly used and accepted term (Orsel et al., 2018). First described in 1974 (Cheli & Mortellaro, 1974), digital dermatitis is an infectious skin lesion commonly found in the interdigital cleft of the foot (Figure 1; Read &

Walker, 1998), but may also be present on other locations (Hernandez & Shearer, 2000).

Pathogenesis

Developing digital dermatitis requires compromise of the skin barrier, most commonly due to mechanical irritation and maceration from moisture and chemicals present in manure (Cramer & Solano, 2024). Once the skin barrier is disrupted, bacteria commonly found in the environment and originating from the bovine gastrointestinal tract can invade the epidermis and dermis, leading to infection. *Treponema* spp. are consistently associated with digital dermatitis and are considered a key component of the polymicrobial infection (Mamuad et al., 2020). As these bacteria spread and damage multiple layers of the epidermis, the host mounts a localized inflammatory response that can result in excessive thickening of the outer keratinized layer of the skin and proliferative lesions (abnormal overgrowth of epidermal tissue) (Döpfer et al., 1997; Berry et al., 2010).

Diagnosis

Digital dermatitis lesions are classified using the M-stage system based on lesion appearance, activity, and tissue characteristics (Figure 2; Döpfer et al., 1997; Berry et al., 2012). **M0** represents normal digital skin with no visible lesions. **M1** lesions are active, ulcerative or granulomatous lesions (<20 mm) that may indicate early or reactivating disease. **M2** lesions are active, ulcerative or granulomatous lesions (#20 mm) and may be further categorized based on lesion characteristics, including the presence of proliferative tissue (M2P) or hyperkeratotic tissue (M2H). **M3** represents a healing stage characterized by scab formation. **M4** lesions represent the chronic stage and are typically non-painful and well-circumscribed. Chronic M4 lesions may be further classified based on the presence of proliferative tissue (M4P), hyperkeratotic tissue (M4H), or focal reactivation (M4.1), which consists of an active ulcerative or granulomatous lesion (<20 mm) occurring within a chronic M4 lesion. Classification of lesion activity is clinically meaningful, as it guides treatment and management decisions.

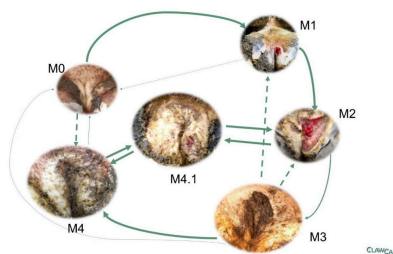
Prevention

Preventing digital dermatitis primarily relies on maintaining good hygiene. Providing cows with a clean environment and minimizing exposure to wet, abrasive surfaces reduces the risk of skin barrier compromise and subsequent infection. The most common preventive strategy is using footbaths. They are typically filled with

solutions such as copper sulfate or formalin and should be at least 10–12 feet long to ensure a minimum of three immersions per rear foot (Cook, 2017). The objective of footbath use is reducing the occurrence of active, painful digital dermatitis lesions, with frequency adjusted as needed to achieve the desired herd-level prevalence.

Higher digital dermatitis prevalence has been associated with herds where animals were recently purchased and with visitor traffic, where boots were not sanitized (Oliveira et al., 2017). Improving biosecurity practices, such as screening animals before they enter the herd and ensuring proper boot sanitation for employees and visitors, may help reduce the risk of introducing and spreading disease.

Figure 2. Illustration of the M-Stage Classification System for Digital



Dermatitis

Sources: Döpfer et al., 1997; Berry et al., 2012

Treatment

The primary goals of topical treatment are to resolve active lesions, reduce pain, and promote transition to a chronic stage. Lesion activity and severity guide digital dermatitis treatment. Active M2 lesions are typically painful and respond positively to topical therapy, necessitating prompt, individualized treatment (Solano et al., 2017). In contrast, M1 and M4.1 lesions are often less painful and may be managed through herd-level control strategies, as outlined in the Prevention section, rather than individual treatment (Bell & Vanhoudt, 2020). This approach supports targeted use of therapeutic interventions based on lesion activity and clinical impact.

Approved treatment options for digital dermatitis are limited and vary by region (Cramer & Solano, 2024). Active digital dermatitis lesions are most often managed using topical products applied directly to the lesion. These include antimicrobial formulations, commonly tetracycline-based powders or pastes, as well as non-antibiotic alternatives that frequently contain copper or other heavy metals. Dairy producers should consult with their herd veterinarian to ensure appropriate product selection and compliance with local regulations and withdrawal times.

Prior to treatment, lightly clean the foot to remove manure while avoiding additional trauma or bleeding. Following application, a wrap may be applied below the coronary band; however, wraps are not required due to the microaerophilic nature of the causative bacteria and may result in additional problems if left in place for more than 24 hours (Cramer & Solano, 2024).

Sole Hemorrhage and Sole Ulcer

Characterization

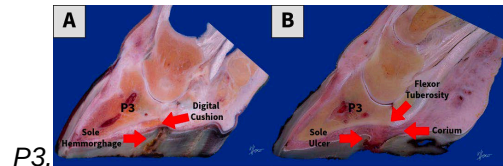
Sole hemorrhages and sole ulcers share similar pathogenesis, risk factors, diagnostic approaches, and prevention and treatment strategies. Both lesions typically occur beneath the third phalanx (P3; see Figure 3) and most commonly affect the lateral hoof of the rear feet (Shearer & Amstel, 2017). The primary distinction between these lesions lies in their severity: sole hemorrhages present as areas of bleeding or discoloration within the sole horn, whereas sole ulcers involve disruption of horn formation, resulting in exposure of the underlying sole corium.

Pathogenesis

Sole hemorrhages result from sustained pressure exerted by the flexor tuberosity of the P3 on the underlying corium, the tissue responsible for hoof horn production (Shearer & Amstel, 2017). This increased pressure arises from alterations in the hoof's suspensory and supporting structures, which may be influenced by both mechanical and metabolic factors. These alterations include the suspensory apparatus, which supports the position of P3 and may become more compliant under the influence of hormones such as relaxin and estrogen (Tarlton et al., 2002) as well as the decreased digital cushion thickness (Newsome et al., 2017), which absorbs mechanical forces beneath P3 and provides less protection when reduced in thickness. As pressure increases, vascular damage occurs within the corium, allowing blood to leak into developing keratinocytes, resulting in hemorrhage visible within the sole horn (Figure 3A).

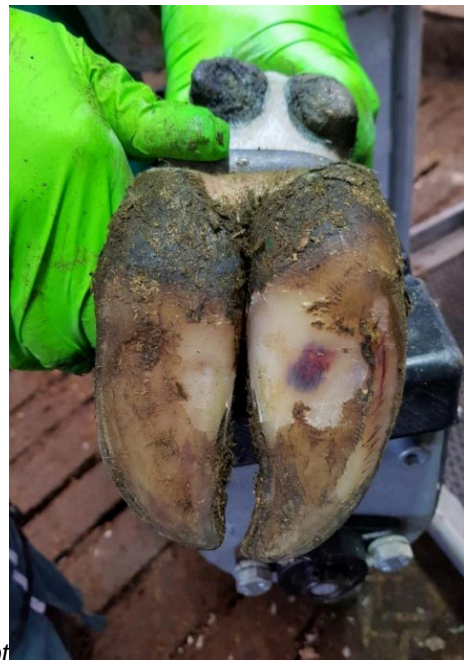
Sole ulcers share a similar pathogenesis to sole hemorrhages; however, prolonged and excessive pressure from P3 over time leads to keratinocyte destruction and disruption of normal horn formation (Shearer & Amstel, 2017). This interruption in horn growth results in a localized horn defect through which the corium may become exposed and protrude, forming a sole ulcer (Figure 3B).

Figure 3. Illustrations of Hoof Damage in Dairy Cows
(A) Sole hemorrhage with labeled structures including the third phalanx (P3), digital cushion, and hoof horn defect.
(B) Sole ulcer with labeled structures including the third phalanx (P3), corium, and flexor tuberosity of the



Diagnosis

Figure 4. Sole Hemorrhage on a Dairy Cow



Sole hemorrhages present as discolored areas within the sole horn, with colors ranging from red and yellow to blue or purple (Figure 4; Cramer & Solano, 2024). Clinical lameness may or may not be evident at the time of diagnosis, as hemorrhages develop within the corium before becoming visible on the sole surface. As a result, sole hemorrhages are often identified during routine hoof trimming rather than through observation of gait abnormalities.

Sole ulcers are identified by localized horn loss with exposure of the underlying corium (Figure 5). The exposed corium may appear bright red in acute cases or brown to necrotic in more chronic lesions. These lesions most commonly occur in the weight-bearing hoof, particularly the lateral hoof of the rear feet.

Prevention

Preventing sole hemorrhages and sole ulcers centers on reducing excessive mechanical pressure exerted by the P3 on the underlying corium. Key strategies include promoting adequate lying behavior, with target lying times of approximately 12–14 hours per day and limiting time away from resting areas to no more than 3–4 hours per day, as well as minimizing negative energy balance and excessive body condition score loss to help preserve digital cushion thickness (Cramer & Solano, 2024). Properly timed and correctly performed hoof trimming is also essential for promoting balanced weight distribution between hooves and reducing focal pressure.

Standing time and body condition score loss are influenced by multiple interacting factors, including stall design and comfort, stocking density, flooring type, heat stress, transition cow management, nutrition, and overall herd management, underscoring the need for a comprehensive, systems-based approach to prevention.

Figure 5. Sole Ulcer on a Dairy Cow Foot and Hoof



Block

Treatment

Treating sole hemorrhages depends on lesion severity and associated pain thickness (Cramer & Solano, 2024). Non-painful hemorrhages that are resolved during routine trimming may be managed conservatively by lowering the heel to reduce pressure beneath the P3. In contrast, hemorrhages that persist throughout trimming and elicit a withdrawal response to hoof tester examination should be treated more aggressively by applying a hoof block to the unaffected hoof to reduce weight bearing on the affected area (Figure 5).

Sole ulcers are treated by carefully removing all loose or undermined horn surrounding the exposed corium

to prevent debris accumulation and facilitate healing thickness (Cramer & Solano, 2024). A hoof block should then be applied to the unaffected hoof to offload weight from the affected area (Figure 5), allowing the corium to heal and promoting horn regrowth.

Ideally, cows fitted with hoof blocks should be re-evaluated within 3–6 weeks to assess healing and to adjust or remove the block as needed (Cramer & Solano, 2024).

Consider using non-steroidal anti-inflammatory drugs (NSAIDs), as inflammation associated with sole hemorrhages and sole ulcers has been linked to developing exostosis (bony growth) of the P3 (Newsome et al., 2016) and deterioration of the digital cushion (Wilson et al., 2021), which may increase pressure on the corium and predispose cows to recurrent lesions.

White Line Disease

Characterization

White line disease encompasses a range of lesion severities affecting the white line region, including:

- **Fissures** (superficial cracks within the white line without loss of structural integrity),
- **Separations** (loss of adhesion between the hoof wall and sole allowing wall detachment), and
- **Abscesses** (localized purulent infection resulting from bacterial invasion through a fissure or separation) (Cramer & Solano, 2024).

Pathogenesis

The exact pathogenesis of white line disease is not fully understood but is postulated to be like that of sole ulcers. The white line is composed of three distinct types of horn, and the horn forming the white line is mechanically weaker than either the sole or hoof wall horn (Shearer et al., 2015). Like sole ulcer development, white line disease is thought to involve weakening of the hoof's suspensory and supporting structures, allowing the P3 to compress the corium responsible for white line horn production (Shearer & van Amstel, 2017). This compression may impair horn formation, resulting in weakened white line horn that is more susceptible to mechanical stress. Under continued loading, fissures may develop, permitting pathogens or foreign material to enter that can damage the corium, promote inflammation, and contribute to lesion progression (Cramer & Solano, 2024).

Figure 6. *White Line Disease on a Dairy Cow*

Foot

Diagnosis

White line disease may present as hemorrhage, separation, or abscess formation and may or may not be associated with pain (Cramer & Solano, 2024). Early painful lesions may appear as subtle white line separation at the sole level, which can progress to abscess formation or the development of draining tracts extending toward the coronary band or bulb of the heel (Figure 6). Abscess development is influenced by lesion stage and disease progression. White line disease is most observed along the abaxial white line of weight-bearing hooves, although lesions may occur in other regions of the white line.

Prevention

Preventing white line disease focuses on minimizing excessive mechanical forces exerted on the white line that may lead to horn damage or separation (Cramer & Solano, 2024). Appropriate flooring is a key preventive measure and should provide adequate traction without being abrasive or slippery. Considerations such as the strategic use of rubber flooring and proper groove sizing and spacing can further reduce stress on the white line. In addition to flooring, facility design that promotes confident cow movement and proper stockmanship that allows cows to move at their own pace can reduce abrupt loading and torsional forces on the hoof. Consistent and strategic hoof trimming is also a key component of white line disease prevention, as it promotes appropriate weight distribution and reduces excessive stress on the white line.

Treatment

Treating white line disease depends on the severity of white line separation and is similar to that of sole ulcers (Cramer & Solano, 2024). Painful white line lesions are treated by removing loose horn surrounding the lesion, including affected wall horn, lowering the heel,

and applying a hoof block (Figure 5) to the unaffected hoof to offload weight from the affected hoof, allowing the corium to heal, and promoting horn regrowth. Cows fitted with hoof blocks should be re-evaluated within 3–6 weeks to assess healing and to adjust or remove the block as needed. Consider administering NSAIDs to limit inflammatory changes to the P3 (Newsome et al., 2016) and digital cushion (Wilson et al., 2021), as described in Sole Ulcer section.

Summary

Hoof lesions are the most common underlying cause of lameness in dairy cows, with digital dermatitis, sole ulcers, and white line disease accounting for the majority of cases in North American herds. Although these lesions may present similar clinical outcomes, they differ in their pathogenesis, risk factors, diagnostic features, and prevention and treatment strategies. Effective hoof health management requires understanding these differences and applying lesion-specific approaches. Early detection and timely intervention are critical, as treatment is generally more effective and less costly when lesions are addressed at earlier stages. While additional hoof lesions can occur, focusing on prevention, accurate diagnosis, and appropriate management of these three prevalent conditions can substantially reduce lameness risk and improve cow welfare and productivity.

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Authors

Drew Swartz, Kalen Taylor, Jacob Hadfield, and Justin Clawson