Digital Dermatitis: Dynamics and Management

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▪ Take Home Message

- Precise diagnosis and classification of digital dermatitis can be used as a tool for managing the disease. A five point system can accurately classify the different stages of the disease.
- Digital dermatitis can increase the occurrence of heel horn erosion.
- Digital dermatitis causes hoof conformation changes even at the early stages of the disease.
- In order to maximize the efficacy of treatment for digital dermatitis and rationalize the total amount of chemical used an appropriate footbath design is necessary. Early topical treatment is the best approach to increase cure rates and decrease the recurrence of digital dermatitis.

▪ Introduction

Digital dermatitis (DD) in dairy cows was first described by Mortellaro in 1974 (Cheli and Mortellaro, 1974). Since then, more and more countries have encountered the disease including countries such as New Zealand and Argentina that have less favorable conditions (for example, cows kept on pasture) for DD development. It is the aim of this paper to review the most up-to-date knowledge about DD dynamics and management. I would like to focus on several practical aspects of DD which are important in the management of the disease. This paper will provide a brief tour from the past to the present, in order to discuss the etiopathology, the classification of the clinical stages and the management practices that are important for control of the disease.

▪ Past

Etiopathology

Traditionally, clinical DD has been defined as a diffuse or circumscribed epidermitis of the skin around the coronary margin of the hoof (Read and Walker, 1998; Blowey, 2005). In relation to the etiology, there is not complete agreement on the primary cause. The microbial component is thought to be multifactorial with spirochetal organisms of the genus *Treponema* playing an important role. In addition, moisture conditions and stressors to the skin (physical or chemical) are important factors in the development of the disease (Rodriguez Lainz et al., 1999; Wells, 1999; Walker et al., 1995).

Disease Classification

A dichotomous system has been used extensively in the field, where cows are identified with DD or not affected at all. In some cases a slightly more precise system of classification was used. It added two categories in the identification of cows affected with DD, where small subclinical lesions or diskeratotic (not active lesions and most of the time not receiving treatment) were differentiated from larger acute lesions (usually treated).

Management

On farms, due to the infectious nature of the disease, two types of approaches have been used in order to decrease the incidence and the duration of DD. The first uses topical treatments based on antibiotic therapy to treat acute clinical cases. The second involves the application of inorganic disinfectants (less commonly antibiotics) by the use of footbaths or sprays, allowing DD treatment and prevention in entire groups of cows.

Despite all the previous advances, we observe less than acceptable DD prevalence on farms (i.e. many articles describe situations where DD prevalence can be greater than 60%; Speijers et al. 2010). Particularly important in heifers, DD is still the number one cause of lameness (NAHMS, 2009). Treatment failure and clinical relapses are commonplace and guidelines to establish optimal preventive programs are not clearly defined. Out of the most common hoof diseases described in dairy cattle (white line disease, sole and toe ulcer and digital dermatitis) DD has been associated with the lowest welfare and economic impact at the individual animal level, but given its high prevalence, DD currently represents a real concern from the economic, animal welfare, and environmental points of view.

■ Present

I would like to briefly review three of the research projects our group at the School of Veterinary Medicine in Madison, Wisconsin is currently working on that address some of the concerns listed above.

Etiopathology

The goal of the first project is to describe the potential hoof conformation changes that occur in feet affected with DD.

It is well described how hoof conformation in dairy cattle changes over time either physiologically or due to the variety of production systems (Bergsten, 2001; Ouweltjes et al., 2011). Decreased production and well-being associated with abnormal hoof conformation have caused a whole trimming industry to be built upon it, with the objective of reestablishing optimal locomotion in lame cows. Specifically for DD, it is easy to recognize the dramatic transformation the feet experience in severe clinical cases. It is not uncommon to observe “square feet” affected with DD, where the heel has overgrown to the point that the affected animal changes its gait, wearing the toe and decreasing the dorsal length of the foot sometimes to the same length as the heel height. As a consequence, there is pain originating from the ulcerated DD lesion and also from the extra wear/trauma of the toe or the white line areas. However, not much is known about the possible hoof conformation changes in less severe stages of the disease; it would be of importance to describe the changes that occur even because of small clinical DD lesions.

For this purpose, a cohort of 500 pregnant Holstein heifers was evaluated 3 times during a period of 6 months within intervals of 3 months. Hoof measurements including dorsal wall length, total length, depth of the interdigital space, heel height, angle of the hoof, hygiene of the interdigital space (scale 1-4, dichotomized to 1-2 vs. 3-4 to be included in the statistical analysis), axial overgrowth of the lateral toe at 35 mm (Figure 1), heel horn erosion (scale 0-3, dichotomized to 0-2 vs. 3 to be included in the statistical analysis), in addition to DD clinical evaluation served to construct a deterministic model explaining conformation changes over time in cows affected with DD.

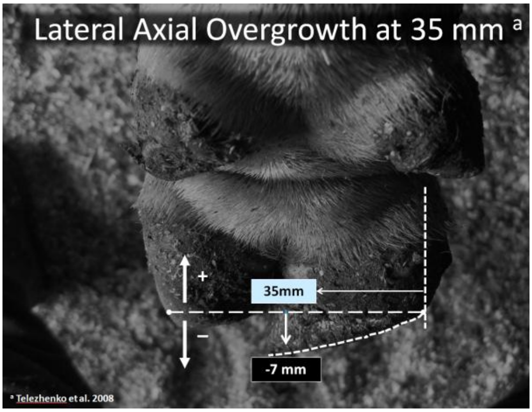

Figure 1. Definition of overgrowth at the axial aspect of the lateral toe.

Desirable conformation characteristics would yield a positive measurement (above the long dashed line) and undesirable growth would show a measure in the opposite direction. The picture shows an example where the medial aspect of the lateral toe is overgrown 7 mm measured at 35 mm from the abaxial hoof wall.

Digital dermatitis lesions were classified upon clinical assessment using the five point method (clinical stages: M0, M1, M2, M4, M4.1) described by Döpfer et al. (1997). Heifers without any lesion identified during the experiment (M0) were used as a reference group to compare with heifers diagnosed with subclinical infections (M1), acute clinical lesions (M2), chronic lesions (M4) or chronic lesions + subclinical infection (M4.1). Figure 2 shows the median lesion size (interquartile range (IQR)) found for each DD stage. Only results comparing M0 to M2 are presented given the particular relevance of acute DD cases. Of note is the median (IQR) size of the M2 cases included in the study (24 mm [21-31]), representing small acute DD lesions and of importance for the interpretation of the results.

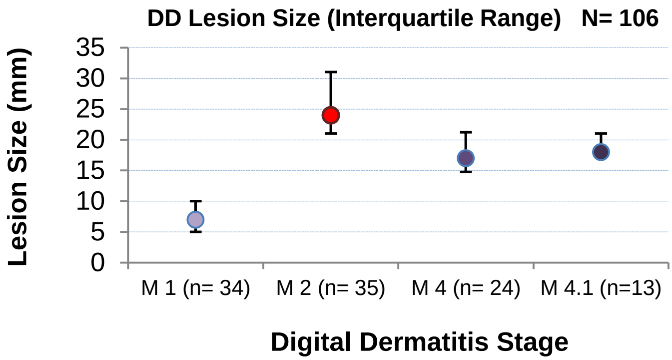

Figure 2. Median lesion size and number of feet (n) included in the analysis of each different stage of DD.

Preliminary results of the study are summarized in Table 1 and Figures 3 and 4. Small DD lesions changed the conformation of the hoof, with the exception of the dorsal and total length. In particular, DD caused an increment in heel horn erosion, an increase in depth of the interdigital space and accumulation of debris in the interdigital cleft. Overgrowth in the axial aspect of the lateral toe was not reduced in feet affected with DD.

Therefore, DD could affect lameness not only through pain but also by changing the foot conformation, increasing the probability of experiencing other hoof diseases such as white line disease or sole ulcers. In addition, it appears that DD could perpetuate its survival when the disease progresses over time. Both arguments would support the idea of early intervention as one of the strategies in managing the disease.

Table 1. Results for the statistical analysis, showing differences observed overtime in each one of the hoof measurements evaluated. Cows not diagnosed with DD have been used as the reference category.

Hoof Measurement	Mean difference (95% CI) between healthy and acute DD (M2) cows			
	Medial	p-val	Lateral	p-val
Total Length (mm)	0.0	NS[1]	1.0	NS
Dorsal Length (mm)	1.0	NS	0.0	NS
Toe Angle (degrees)	**1.9** (0.1, 3.6)	<0.05	**1.5** (0.1, 3.0)	<0.05
Heel Height (mm)	**4.02** (1.5, 6.4)	<0.05	**2.64** (0.7, 4.5)	<0.01
Depth Interdigital Cleft (mm)	**4.9** (3.7, 6.0)			<0.01
Axial Overgrowth Lateral Toe at 35 mm (mm)	**-0.77** (-1.60, 0.00)			0.07
Interdigital Hygiene (1-2 vs. 3-4) %	**0.27** (0.08, 0.46)			<0.01
Heel Horn Erosion (1-3 vs. 4) %	**0.42** (0.31, 0.52)			<0.01

[1]NS= Not significant

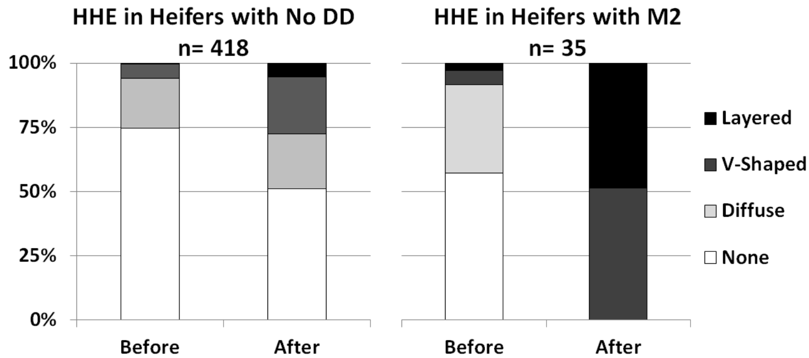

Figure 3. Percent of legs diagnosed with Heel Horn Erosion in heifers at enrollment (Before) and at evaluations 2 and 3 (After) depending on DD (M2) status.

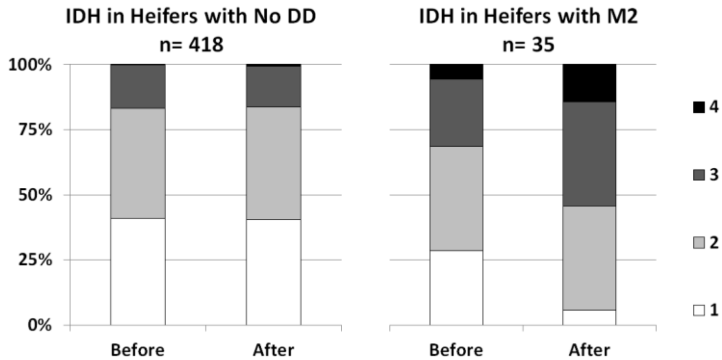

Figure 4. Interdigital Hygiene score (IDH) observed in heifers at enrollment (Before) and at evaluations 2 and 3 (After) depending on DD (M2) status. [Score 1= clean interdigital space to Score 4= interdigital space fully filled with debris]

Disease Classification

During the last 15 years the research community has largely used the five point classification system described by Dopfer et al (1997) to characterize the different clinical stages of DD With this information, we have been able to repeatedly observe how chronic stages of the disease can transition to clinical acute stages or how subclinical lesions can fade out to a healed stage without receiving any treatment. Having this information would make it possible in the field to identify periods of higher risk for the occurrence of DD by observing an increase in subclinical infection. Additionally, higher sophistication in data recording is flooding the dairy industry, with the appearance of very affordable electronic devices and software programs allowing the storage and management of more extensive information. In our opinion, there is no excuse not to use the most accurate classification system available, and profit from that information to monitor the effectiveness of DD control programs and change management practices accordingly.

Management

The second study evaluated how different footbath designs can affect the efficacy of the treatment by measuring the number of feet immersions per cow pass (Cook et al. 2012).

It is unquestionable that the use of footbaths in control programs for infectious hoof diseases is necessary but the chemicals used in footbaths are expensive and also cause environmental concerns. Paradoxically, the literature evaluating the efficiency of different footbath designs is sparse. Even the research developed to evaluate the efficacy of chemicals in reducing DD has not been performed by using a standard footbath design, making it more difficult to compare products tested in different studies.

For the purpose of observing the behavior of the cow when passing through the footbath, a pen of 90 Holstein milking cows was chosen for the duration of the study. We hypothesized that the design of the bath influences the number of feet immersions received as the cows pass through the footbath. Video-cameras were installed to record the number of dunks the rear feet experienced. Two milkings from two consecutive days were recorded for each one of the bath settings. Four different bath arrangements were tested (Length (L) and Width (W) shown in meters): a. 1.8 L X 0.76 W, b. 2.4 L X 0.6 W, c. 3.0 L x 0.5 W and d. 3.7 L x 0.5 W. The design was made to achieve a similar solution of ~200 liters. A step in height of 0.28 m was tested for all settings, and an additional 0.15 m step in height for the two shortest bath lengths.

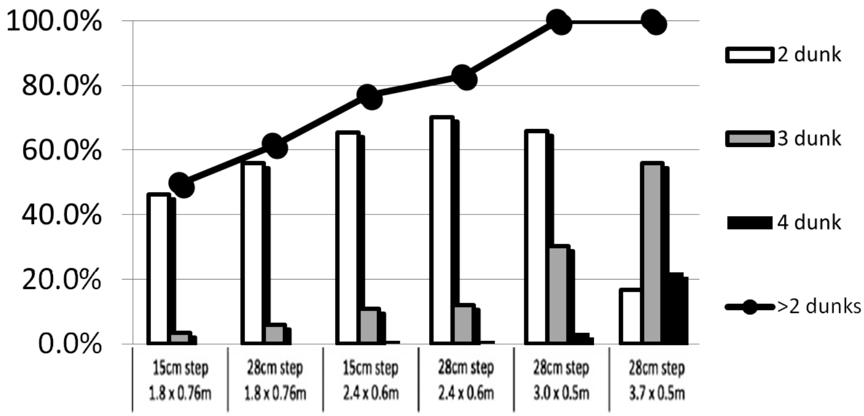

Figure 5. Mean frequency of immersions (dunks) per cow (bars) and percent of cows with more than two dunks (line) for each footbath setting. Differences shown in the diagram are statistically significant at $\alpha = 0.05$ with a p-value< 0.001.

Results from the study are summarized in Figure 5. It is common sense that as the bath length was increased, cows needed to step inside more times to be able to pass through it. Multinomial logistic model analysis has shown statistically significant differences in the number of immersions between the different settings having a p-value < 0.001. Of note are: first, the dramatic increase in the number of dunks with only a small increase in bath length and second, the same total amount of treatment solution kept for all of the settings. The effect of step in height in the total number of immersions was also statistically significant, and because we did not observe any harmful effect on cow flow with the higher step in height, the two longest baths were only evaluated using the 0.28 m step-in. Based on the maximum number of immersions observed during the study, and aiming also to minimize the use of the solution, a proposed footbath design is outlined in Figure 6. It is true that our trial does not test the efficacy of different footbath dimensions in reducing DD clinical cases. However, a recent trial published by (Logue et al., 2012) shows how the effect of increasing the length of the footbath, has a strong influence in reducing the prevalence of DD (Table 2).

The dairy industry has traditionally used footbaths designed with less than 2 m in length despite the limited research supporting it. It is our strong believe that more efficient bath dimensions can maximize the efficacy of the treatment administered and help to optimize the results of DD control programs where footbaths are used.

Table 2. Results from a multivariate model examining different factors on the reduction of DD in a group of cows examined three times during a period of 6 months. The table shows the odds of having DD prevalence reduced between examination one and examination three (6 months interval). Extracted from Logue et al. 2012, Veterinary Journal 193: 664-668

Change from examination one to examination three (including cow or farm as a random effect).

Variable	Odds ratio	95% Confidence interval	*P* value	Rho
Number of footbaths				
One (ref)	1	2.07–5.19	<0.001	
Two	3.3			
Lactation number	1.13	1.02–1.25	0.02	
Product $CuSO_4$ (ref)	1	1.14–2.32	0.007	
Trial product	1.6			
Cow				0.24
Number of footbaths				
One (ref)	1	1.67–3.71	<0.001	
Two	2.49			
Lactation number	1.11	1.02–1.21	0.01	
Product $CuSO_4$ (ref)	1	1.1–2.08	0.01	
Trial product	1.5			
Farm				0.002

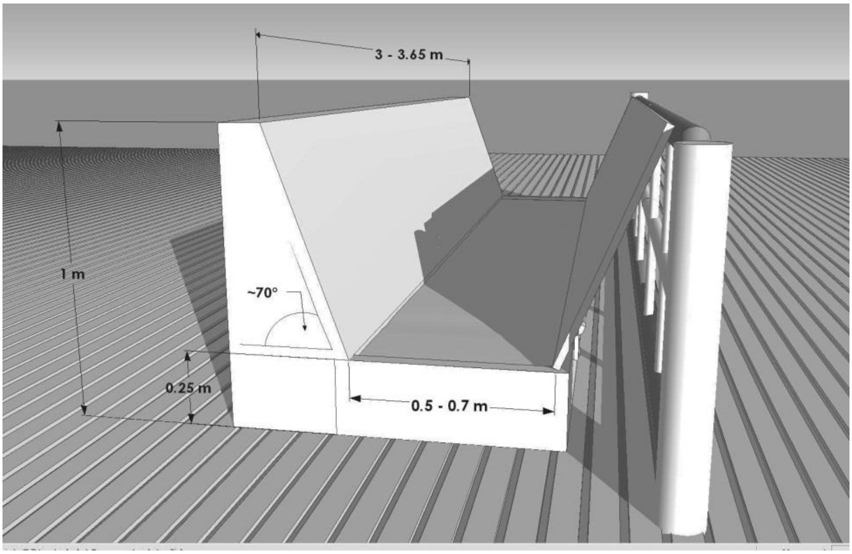

Figure 6. Footbath design proposed to maximize the number of feet immersions and minimize the use of treatment solution.

The third study aimed to observe histopathologically how acute DD lesions progress over time.

One of the challenges we currently face is how to avoid recurrence after DD lesions have been treated by using footbath solutions or more importantly after topical treatment has been applied. We already know that DD lesions tend to perpetuate themselves by changing the physical characteristics of the skin and the hoof horn, so delayed treatment is likely to be less efficacious and to have more relapses to a clinical stage. Also, we have recently observed “in vitro” that under stress conditions (unfavorable environment for growth such as aerobiosis, contact with certain chemicals, etc.), *Treponema* spp. microorganisms, considered as the most important bacterial component in DD etiology, migrate from active to cystic forms.

With the objective of analyzing qualitatively the distribution of the bacterial population involved in DD lesions, we evaluate histopathological samples taken from DD lesions. The lesions included in this study were evoked experimentally by means of an infection model developed by our research group (Gomez et al., 2012). The advantage of using experimental DD lesions is that they are early lesions where processes associated with chronicity such as hyperkeratosis have not developed yet, eliminating interference with treatment. Four biopsies were taken from 30 experimental DD lesions: upon diagnosis (treated right after with topical Oxytetracycline), and after the 1st, 2nd

and 4th week after treatment. The samples were processed histopathologically using Hematoxilin-Eosine, Giemsa and modified-Silver stains.

In fresh lesions (at diagnosis), we observed histological characteristics compatible with DD, where microorganisms were found as deep as the dermis stratum of the skin. In all cases the clinical healing process was adequate, showing typical signs of skin recovery after treatment. Despite the healthy clinical appearance, bacterial debris could be observed at the dermis and epidermis level even in biopsies obtained 4 weeks after treatment.

Treponema organisms can potentially develop to encysted forms under the presence of chemical or physical stress. The bacterial clearance of the dermis is a slow process even in early DD lesions experiencing optimal clinical cure. Delayed treatment is likely to favor skin reaction against the disease, thus, it is not surprising that we find high rates of treatment failure and lesion recurrence under field conditions. Prompt topical treatment of early lesions appears to be the best approach to minimize possible recurrence and maximize clinical cure rates.

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