Lameness in Cattle with a Focus on Conformation, Foot Trimming and Cow Comfort

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Lameness is an important disorder in dairy cattle, and the economic costs as a result of reduced milk production, impaired fertility, higher odds of culling, and treatment are high. Much work has been done looking at the heritability of hoof lesions and although the heritability has been found to be low, there is considerable genetic variation as evidenced by the large variability in sire EBV (Chapinal et al., 2013). In addition, the genetic correlations between hoof lesions and conformation traits has been low showing no correlation with infectious lesions and only small correlation with horn lesions (Chapinal et al., 2013). The Lifetime Performance Index (LPI) is greatly influenced by feet and leg conformation traits and its value as a breeding tool would seem to be compromised without a more positive correlation for resistance to hoof lesions. It is reasonable to assume that the pathway for infectious hoof disease such as digital dermatitis is very different from the non-infectious disorders and the genetic component of the pathways will therefore also be different. When digital dermatitis is excluded, genetic correlation of hoof disorders increases significantly (Weber et al., 2013). Recently, on a large New York dairy farm the heritability of digital cushion thickness was found to be 0.33, while a strong negative genetic correlation was found between digital cushion thickness and claw horn lesions (Oikonomou et al., 2014). Therefore, it is useful to review the current foot conformation traits used and investigate the possibility of identifying other conformation foot traits that may improve the association with specific hoof lesions. It would also be useful to reevaluate the emphasis given to each of the five current feet and leg traits in the LPI index. Heel depth is one of the current conformation traits that is evaluated, but it is not known whether there is a relationship between heel depth and digital cushion depth. Also, the depth and width of the cleft between the heels has been suggested as a trait involved in hoof health but this has never been confirmed. Finally, the angle of the hairline at the coronary band has been used by classifiers to evaluate the foot angle and help to adjust for the differences in the foot angle before and after trimming. An actual measure of the foot angle before and after trimming would be helpful to identify the correlation between the actual foot angle and the classifier’s linear scores for this trait.

The other major issues impacting lameness and foot health include cow comfort and foot trimming. With regard to foot trimming, the trimming technique varies among trimmers and it is useful to review the different trimming techniques as well as the trimming goals with regard to toe length, foot angle, heel depth, and sole thickness. There is little peer reviewed literature evaluating different trimming techniques, however, differences seem to arise from three major inconsistencies in the trimming technique:

1. The appropriate length to cut the dorsal wall
2. The landmark of the proximal limit for measuring the dorsal wall length
3. Whether to trim the toe to a point or to leave a step

It is clear that the second two points must be addressed before the first can be answered. The trimming technique most commonly used by professional trimmers, and now used for their accreditation process, is the “Dutch Trimming” method introduced by Dr. Toussasint Raven more than 30 years ago. Dr. Raven acknowledged that “normal length varies with breed and age” but he stated that “7.5 centimeters is a safe size for an adult Friesian Cow”. While this length seems to have become an industry standard, it is important to note that Dr. Raven did not define a specific landmark for the proximal dorsal wall limit and did not specify whether the 7.5 centimeter length applied to a toe that was trimmed to a point or left as a step. With the “Dutch Trimming” method currently being taught today and being used in the
accreditation process, the toe is left as a step rather than being trimmed to a point. In subsequent foot trimming literature, a genuine attempt has been made to precisely identify the proximal landmark for measuring the dorsal wall length and for identifying the trimming technique used at the toe. The step technique for trimming the toe is particularly helpful for new foot trimmers since it allows them to view the sole thickness from the distal flat end of the toe and to fully appreciate the relationship between the toe length and the sole thickness. However, it has been recognized by Archer et al (2015) that “different trimming techniques would require adaptation of dorsal wall length to achieve sole thickness”.

In order to define a specific proximal landmark for measuring toe length, Mulling and Budras (2003) reviewed the anatomy of the claw and concluded that the coronary band produces wall horn deep to the periople and that the perioplic horn borders the common integument and overlies the proximal limit of the wall horn. Therefore the junction between the hoof horn and the common integument appears to be the most consistently definable landmark for measuring the dorsal wall length as seen in the image below:

![Image of foot anatomy highlighting the proximal landmark for measuring toe length.](image)

A green pin marks the proximal limit of the wall horn and an asterisk demonstrates the distal tip of the border between wall and dermis. A red pin identifies the proximal limit of the perioplic horn.

Experienced foot trimmers vary claw length where the aim is to correct foot angles for optimal weight bearing. In a recent research project, the author found experienced trimmers restored over 90% of trimmed hind feet to a foot angle between 48 and 52 degrees. In order to assess the appropriateness of the 7.5 cm dorsal wall length recommendation, Archer et al (2013) made use of CT imaging on cadaver feet to correlate outer measurements with inner anatomical structures. A cross-sectional sagittal image of the foot was used to identify the distance from the proximal limit of the wall horn to the tip of the dermis at the toe. The minimum recommended external wall length was estimated by adjusting the internal wall length to accommodate a 5 mm sole thickness, a claw angle of 50 degrees, and trimming the toe to a point. To complete these calculations it was necessary to know the thickness of the dorsal wall and it was determined to be 8 mm. Now by using trigonometry, it was possible to calculate the minimum recommended external dorsal wall length based on these constraints and the CT measured internal dorsal wall length. It was concluded in this study that the external dorsal wall length must be at least 14 mm greater than the internal dorsal wall length when trimming the toe to a point. It becomes obvious from this calculation that the external dorsal wall length must be greater when the toe is trimmed to a point and that the toe may be 5 – 7 mm shorter if it is trimmed in the step configuration. The angle of the step configuration cut recommended by Dr. Raven is achieved by having “the handles of the tool in line with the bottom surface of the claw”. In most cases this should result in a cut that is
perpendicular to the bottom surface of the claw rather than to the dorsal surface of the wall as was indicated in Archer’s diagrams below:

Archer et al noted that with this method, applying a dorsal wall length of 75 mm would have been too short for 95 per cent of claws overall. Trimming to 85 mm would have been adequate for animals less than four years of age (assumed to be in first and second lactation), but too short for 34 per cent of claws from cows aged at least four years. If the dorsal wall were cut to 75 mm leaving a step, 55 per cent of claws would have been cut too short. Archer and his group acknowledge that it is unlikely that experienced trimmers will use one cut length for all cows, but will vary it, for example, by size of cow or foot. However, where fixed lengths are to be applied at a population level, caution must be taken to minimize the proportion of claws for which that length is too short. Where fixed lengths are used to simplify protocols and facilitate the training of farm staff and other less experienced operators, their study suggests the minimum recommended length for trimming the external dorsal wall should be at least 90 mm for Holstein-Friesian cows, to reduce the risk of overtrimming.

NON-INFECTIONOUS CAUSES OF LAMENESS IN THE FOOT

The thin sole syndrome is a condition created either by trimming the toe too short or by creating a situation of severe over-ware from cement footing and abrasive sand used for bedding. Especially in situations where cows must walk long distances to and from the milking parlor, the hoof wear often exceeds the new hoof growth and the sole becomes dangerously thin. The use of rubber mats in alleys used to move cows may be a solution however foot trimming may also have to be modified. One of the most common outcomes from thin soles is bruising or hemorrhage of the sole. There may be no other hoof disease causing a severe lameness other than subsolar bruising or exposure of the corium at the white line. Individual animal treatment is to apply hoof blocks to allow regrowth of the over-worn and bruised sole. As a herd problem, environmental modification is indicated and usually means installing rubber in the holding pen and travel lanes to and from the parlor. Sole hemorrhage is characterized by slight to significant red or blue coloration of the sole.
Ulceration of the sole may occur in any digit but is most common in the lateral claws of the rear feet and the medial claws of the front feet. The typical site for ulceration is in the corium that overlies the flexor process of the third phalanx and it is often referred to as a “Rusterholz Ulcer”. The central fat pad of the digital cushion protects this area from the trauma that results when the heel strikes the ground. With normal locomotion, the heel strikes the ground before the toe and the pedal bone at the heel is not suspended to the hoof wall by the network of collagen fibers as it is at the toe. Therefore, the cushioning property provided by the digital cushion is extremely important in preventing trauma to the corium beneath the flexor process. These anatomical relationships are illustrated in the images below: Trauma to the area beneath the flexor process creates hemorrhage at the corium resulting in destruction of the integrity of the sole, necrosis, and the development of an ulcer as the sole grows out to the wearing surface. When the outer claw of the hind foot is involved, the limb is typically held in an abducted position with the weight borne on the medial claw. The natural overgrowth of the lateral hind claw results in external rotation of the toe and the cow adopts a “cow-hocked” stance. In some cases there may be a thick wedge of horn extending over the axial wall that must be trimmed to expose the lesion. As the sole horn is trimmed, a defect may be found in the sole horn that exposes the corium or a mound of granulation tissue. The loss of the sole horn in this area allows infection to involve the deeper structures of the foot, most notably, the navicular bursa, the distal inter-phalangeal joint, the heel bulb, and the deep digital flexor tendon.

It is important to understand that the environment to which the cow is exposed also has a great influence on the prevalence of sole ulcers. Poor stall and facility design lead to inadequate lying times and if cows are confined to cement the constant trauma leads to a dramatic increase in trauma to the corium and consequently more sole ulcers. Nutrition is also an important factor to facilitate the proper supply of nutrients for building healthy hoof tissue and the proper metabolic environment for hoof production.

Before starting treatment, it is important to identify signs of deep sepsis of the claw often referred to as Deep Digital Sepsis (DDS). Infection may extend to the deeper tissues of the foot and result in any of the following disease states: cellulitis, septic osteitis/osteomyelitis of any of the phalanges and/or the navicular bone, septic tenovitis of the flexor tendons/sheaths, or septic arthritis of the interphalangeal joints or navicular bursa. Infection of the deep flexor tendon may be characterized by swelling along the course of the tendon. In severe cases the tendon may rupture resulting in an upward rotation of the toe. Septic arthritis of the distal interphalangeal joint should be suspected when swelling is present above the coronary band on the cranio-abaxial aspect of the claw. Radiographs may be necessary to confirm the diagnosis unless there is a rupture of the joint capsule and obvious drainage from the joint. Infection of the heel bulb manifests as severe swelling in the heel region. All of these complications
carry a poor prognosis and treatment usually involves aggressive surgical intervention that is expensive and time consuming.

Assuming the sole ulcer is uncomplicated by secondary infection, the most important treatment is corrective trimming of the foot. First the under-run and necrotic horn should be removed in order to facilitate healing and second and most importantly, trimming of the foot should normalize weight bearing and remove one of the most important causes of the sole ulcer. A number of prosthetic blocks are commercially available for the treatment of lame cows and can be extremely useful for the healing of sole ulcers. The principle of the treatment is that the block is applied to the uninjured claw, thereby elevating the affected claw, removing weight bearing, and giving it a chance to heal. It is essential to ensure that the block is placed well back on the claw to give support to the heel and allow for the forward migration of the block with the normal hoof growth.

The use of dressings to treat sole ulcers is controversial since the benefits achieved by the protection and topical medication of the lesion must be balanced with the likelihood that the bandage will absorb much manure and urine and prevent the ulcer from draining properly. It should be noted that most hoof trimmers and veterinarians bandage sole ulcers at least for a short period of time immediately following opening and debriding. Breakdown of the suspensory apparatus associated with the release of matrix metalloproteinases leads to sinking and rotation of the third phalanx. The result is pressure on the solar corium in zone 5 and in the worst case scenario, the solar corium and P3 may actually prolapse through the sole. In cattle the breakdown of the suspensory apparatus leads to weakness and elongation of collagen fiber bundles whereas in the equine, a true separation of the dermal-epidermal junction is more likely to occur. The structural features of the white line make it the softest and least resistant part of the claw capsule and subject to damage by mechanical shearing forces and the penetration of bacteria and foreign bodies. The area of the white line most commonly affected is the abaxial heel-sole-wall junction of the lateral claw (zone 3). This area of the foot is predisposed to the greatest mechanical impact and wear during locomotion since it is the first contact point during the foot placement phase of the stride. Overgrowth and overloading tends to exacerbate this load bearing issue.

White line lesions in zones 1 and 2 tend to occur less commonly since the white line in this area does not have to withstand mechanical impact to the same degree. Lesions normally begin as small cracks or spaces within the white line that become infiltrated with organic matter. Abscess formation associated with white line disease often accumulates in the subsolar region of the toe or in many cases it may migrate upward beneath the wall. In the worst case scenario, infection may extend into P3 resulting in an osteitis which is a very painful and chronic condition.

**INFECTIOUS CAUSES OF LAMENESS IN THE FOOT**

*Digital Dermatitis*

By definition Digital Dermatitis is an acute inflammation of the hairy skin. It may be spread into the interdigital cleft or undermine the bulb of the heel thus including the modified skin of the claw. Although the foot is extremely painful, and the affected animal very lame, there is usually no associated digital swelling or fever as is the case with foot rot. Because the lesion and the pain is usually concentrated in the heel area, affected animal try to carry most of their weight on the toe and this leads
to other lesions such as toe ulcers. The precise cause of digital dermatitis is still being debated but it is generally accepted that the causative agent is a Treponema spirochaete. In fact Choi et al have identified at least 5 different species of Treponema responsible for the disease.

The disease was first reported in Italy in 1974 by Cheli and Mortellaro but it has now been described around the world. Other names used to refer to the disease include: Hairy Hoof Warts, Strawberry Heel, Raspberry Heel, and Mortellaro’s Disease. The typical lesion is first seen as a moist, foul smelling, exuding area with matted superficial hairs at the back of the foot just between the bulbs of the heel. The lesion goes through a progression where it begins concave as a result of tissue loss but it soon becomes flat with a towel like surface. In the chronic form, digital dermatitis is characterized by raised or thickened lesions with filamentous epithelial outgrowths. When the area between the claws becomes infected, the disease is often referred to as interdigital dermatitis but this disease has its own unique causative agent. Since the disease has not been successfully transmitted, it is obvious that there are other predisposing factors that are important in the development of the disease.

Although the disease is almost impossible to eradicate, treatment response has generally been quite good. Topical treatment with tetracyclines, lincospectin and formalin are the most common. Treatments are delivered either by footbaths or topical sprays and work done by Dr. Chuck Guard would suggest that there is very little advantage to wrapping provided the lesion is clean when the treatment is applied. Autogenous and commercial vaccines have come and gone with none proving efficacious in preventing the development of lesions.

(Digital Dermatitis Images Below are Courtesy of Dr. Gordon Atkins and Dr. Paul Greenough)

**Interdigital Dermatitis**

Chronic interdigital dermatitis is caused by infection with Dichelobacter nodosus and is very common in cattle that live in moist environments. The infection produces a mild irritation that results in underlying skin hypertrophy which may result in an interdigital fibroma (corn) or excessive horn accumulation along the axial wall. If the infection spreads across the heels it may erode the horny portion of the heel in irregular patterns. Dichelobacter nodosus produces proteases that are capable of digesting the keratin of hoof tissues. Lameness results from interdigital dermatitis when the cracks in the heel combined with
hypertrophy of the heel bulb change the weight distribution to increase pressure on the heel. Affected cows tend to paddle and try to avoid bearing weight on the heels. This condition is also referred to as stable foot rot or slurry heel but it is distinctly different from foot rot.

The use of systemic antibiotics is not warranted since the cleaning, drying, and use of topical antibiotics have proven very successful. Topical tetracycline spray or copper sulphate foot baths are the two most common treatments. Prevention is achieved through good management to create hygienic conditions, regular foot trimming, and regular use of foot baths.

Foot Rot

Although foot rot is the common term used in North America, other terms used to describe this disease are: Interdigital Phlegmon, Foul in the Foot, and Interdigital Necrobacillosis. The disease is caused by Fusobacterium necrophorum possibly in association with Bacteroides melaninogenicus. Both organisms are found in the feces of normal cows but it is thought that trauma to the interdigital skin is needed before the organisms can gain entry and chronic exposure to moist environments is sufficient for this. Whereas digital dermatitis is an infection of the superficial layers of the skin, the characteristic of foot rot is that it produces a toxin that causes necrosis and tissue degeneration in the deeper dermis. In untreated cases the massive associated swelling may track up the tendon sheaths of the leg and may penetrate into the pedal joint itself. Foot rot is characterized by a febrile response, systemic antibiotics are indicated, and the response is quite good if treatment is initiated early. If foot rot is not treated, the course of the disease will be prolonged and the risk of complications will increase. Although penicillin has been an effective treatment for many years, recently treatment has been less successful and many of the broad-spectrum antibiotics have been used instead. In particularly severe cases, regional perfusion of the tissue with intravenous antibiotics administered in the digital vein with a tourniquet in place, have proven to be a useful new treatment strategy.
Heel Erosion

Heel erosion, or slurry heel as it is often called, involves both the hoof and skin tissue and Dichelobacter is the most commonly associated pathogen. In housed dairy cows, which stand for long periods in wet, corrosive slurry, the normal smooth, intact horn of the heel becomes eroded and pitted and may become totally worn away. The overall effect of this is to rotate the hoof backwards. The fetlock drops, the front wall of the hoof forms much more shallow angle with the horizontal and the toe may lift from the ground and no longer be weight bearing. More importantly, internally, the pedal bone rotates towards the heel and may pinch the corium causing a sole ulcer.

REFERENCES


