Toe Lesions in Dairy Cattle

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For the past several years these authors have been studying toe lesions in cattle with a specific interest in their pathogenesis and underlying causes. Our work to date indicates that there are 5 conditions that typically predispose to lameness and toe lesions. These include: toe ulcer, white line disease, thin sole toe ulcer, corkscrew claw and trauma-related lesions affecting the tip or apex of the claw. In our experience, toe ulcers associated with laminitis are relatively rare. White line disease lesions in the toe are slightly more common and are sometimes associated with inappropriate trimming techniques (i.e. such as excessive removal of the axial or inside wall). Laminitis is believed to be a potential contributor to white line lesions in the toe as a result of its effects on horn quality. Corkscrew claw is relatively common and frequently predisposes to toe lesions that result in abscess formation by a couple of different routes. Trauma-related lesions that result in toe abscess formation are more common in feedlot cattle where hyper-excitable animals are prone to traumatic injuries of the toe during processing or hauling. For dairy operations throughout the Southeast, one of the most common lesions is the "thin sole toe ulcer" (TSTU). This lesion is a consequence of excessive thinning of the sole associated with accelerated claw horn wear and on occasion over-trimming. These lesions are particularly prevalent, difficult to treat and predispose to lesions that frequently result in chronic lameness. In the following we describe these lesions with particular emphasis on discussion of the TSTU.

INTRODUCTION

Toe lesions in cattle are common causes of lameness. In housing systems where the rate of sole horn wear exceeds the rate of growth excessive thinning of the sole is likely to occur. Previous work has demonstrated that claw horn hardness is influenced by nutrition, contact with manure slurry and moisture content of claw horn[18]. Claw horn is continually exposed to high moisture conditions particularly during the hot and humid summer months. Heat stress abatement procedures require that cows have access to sprinklers and fans, misters or high pressure fogging systems. Claw horn moisture content is also affected by manure management systems based on flushing of fresh or recycled water to clean floors in barns, holding areas and travel lanes. Wear rates are also affected by the spatial layout of facilities which require cows to walk long distances to and from barns and milking areas. This is exacerbated by abrasive flooring conditions that include sharp turns and sloped walkways.

Excessive sole horn wear is especially common in new installations where freshly hardened concrete creates a particularly abrasive surface as a consequence of the presence of surface aggregate which naturally forms on the flooring surface as the concrete cures. This observation has become so commonplace as to have its own name "New Concrete Disease" [2, 4, 12].

The occurrence of thin soles is also influenced by conditions contributing to poor cow comfort such as overcrowding and reduced stall use due to improper stall design and insufficient bedding. Issues of dominance also affect stall use. When stall numbers are equivalent or less than the total number of cows in the barn, timid animals such as heifers may have less opportunity to rest. Some recommend that there be at least 10% more free stalls than cows to permit more choice and encourage lying time. Generally speaking, stall design should accommodate the following resting behaviors: 1) Ability for the cow to stretch front legs forward. 2) Ability to lie on its side with sufficient space for the head and neck. 3) Ability to rest its head on its side. 4) Sufficient room for the cow to rest its legs, udder, and tail on the free stall platform and have a clean, dry and soft bed. Some US recommendations for Holstein cattle include construction of a free stall 8 ft (2.5m) long [7ft 6in. (2.28m)] for two facing rows) and 4 ft (1.25m) wide with a brisket board 15in. (38cm) high and located 5ft. 8in. (1.72m) from the stall curb. Even longer free stalls up to 9ft.8in. (2.94 m) are currently recommended by some [21].

The possibility of over trimming should always be ruled out whenever thin soles are identified as a herd problem [21]. Different trimming methods can result in significant differences in sole thickness. For example, one study found that the method commonly referred to as the Dutch method of claw trimming resulted in fewer thin soles compared to another method, which used the white line as a guide to estimate sole thickness [17]. The Dutch method uses toe length as a guide to estimate sole tickness[15, 17]. For the average adult Holstein cow a toe length of 3 inches (7.5cm) corresponds to a sole thickness of 0.25 inches (5-7 mm), which under normal circumstances of growth and wear provides enough sole horn to protect the corium (the quick underlying the sole horn)[15, 17].

CLINICAL OBSERVATIONS

Thin-soled cows were identified in 2 large dairy herds consisting of 3221 (herd 1) and 2200 (herd 2) lactating cows each during examination of animals presented with clinical lameness over a one year period. Cows in both herds were kept in free stalls with sand bedding and grooved concrete walk ways. Some of the cows in herd 2 had access to dirt lots when weather permitted. The incidence of thin soles for herd 1 for the period was 30.1% (32.6% for 1st lactation cows) and 12% for herd 2. Criteria established in a previous study served as a basis for the diagnosis of thin soles, which included a short dorsal wall (less than 7.5 cm/ 3 inches) and a soft flexible sole on thumb pressure. Back feet (particularly the outer claw) were more commonly affected[18]. Lesions other than thin soles observed in this study included: a) hemorrhages in all claw zones but primarily in the abaxial sole/white line region in zones 5, and1 and 2, respectively; the heel sole

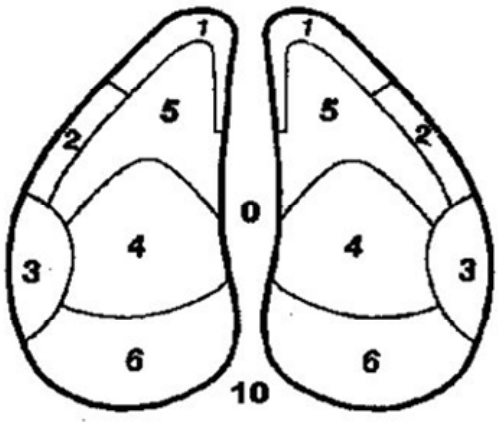

Figure 3. Claw Zone Diagram: 1) White line at the toe, 2) Abaxial white line, 3) Abaxial heel-wall junction, 4) Sole-heel junction 5) Apex of the sole, 6) Heel

junction (zones 4 and 6) and axial area of zone 4; b) sole ulcers particularly in zones 4 (typical site for sole ulcers) and zone 6 (heel ulcer), and c) break or separation of the sole from the white line which exposes the underlying corium (See Figure 1).

Observations made in herd 1 during the above period showed that the highest incidence of thin soles occurred in second lactation cows between 60 and 250 days in milk [20]. In both herds the highest overall incidence of thin soles occurred during the summer months [13, 20]. Thin-soled cows that develop lameness generally present with one of the following conditions:

1. Thin soles that are flexible to finger pressure but have no ulceration thus no exposure of the underlying corium
2. Thin soles that are flexible to finger pressure and have a break in the epidermis that exposes the underlying corium (thin sole toe ulcer)
3. Thin soles that have progressed beyond the stage of ulceration to the formation of a subsolar abscess at the toe (toe abscess). At this stage the white line may also become involved. Infection can cause necrosis of both the laminar corium and laminar horn (white line)
4. Thin soles that have progressed to the point of subsolar abscessation and osteitis of the third phalanx [14, 16] (complicated toe abscess with osseus sequestration)

Because of good lameness detection in both herds 1 and 2 most cows that presented with thin soles fell into the categories described in 1 and 2. A few cases were more consistent with the lesions as described in categories 3 and 4. The exact number in each category was not captured in records for either herd.

TREATMENT AND MANAGEMENT OF THIN SOLED COWS

Treatment of thin-soled cows requires careful evaluation of the sole of all claws. Generally speaking, thinning and thus flexibility of the sole is greatest on the lateral claw of rear feet and the medial claw of front feet. The first objective in treatment is to determine if the more sound of the two claws being evaluated on each foot can support the weight on that limb if fitted with a foot block to relieve weight bearing on the thin-soled claw. If the answer yes, then a block is fitted to the most sound (claw with the healthier and thicker sole) of the two claws. On the other hand, if it is determined that neither claw can support the weight of the respective limb, then neither claw should be fitted with a block and the animal should be housed in an area free of concrete or other hard surface. Special needs areas that are close to milking facilities and designed with soft flooring surfaces may be used. An alternative to housing in special needs areas is a grassy area, or drylot close to the parlor that limits the distance cows must walk on hard or abrasive surfaces during the period of time desired for recuperation and horn growth.

In cases where the condition has progressed to the point of ulceration, subsolar abscess formation or osteitis of the third phalanx, additional corrective trimming and debridement procedures are necessary. All loose and undermined claw horn associated with the lesion should be carefully removed without causing damage to adjacent tissues of the corium. Sole horn separation from the corium can become quite extensive in

cases where the solar corium has become traumatized and infected with the formation of a subsolar abscess. Apart from formation of a subsolar abscess the infection may spread into the white line resulting in necrosis of the white line with separation from the wall. The overlying separated portion of the wall should be removed to the point where reattachment between the wall and healthy corium is evident.

Because the corrective trimming procedures can be very painful, local anesthesia may be necessary. Local anesthesia is essential for those conditions that require significant debridement of soft tissues and bone. The objective in every case is to remove all necrotic tissue without causing damage to adjacent healthy corium. The adjustment of weight bearing by means of a foot block is important for management of pain as well as subsequent recovery of the horn-forming tissue of the epidermis.

There seem to be many opinions among clinicians as to the best treatment for open lesions involving the corium. The treatment approach favored by these authors is that small lesions which result in minimal exposure of the corium be left untreated. On the other hand, when faced with larger lesions in which there is significant exposure of the corium, these authors prefer to apply a non-irritating topical ointment such as Silver Sulfadiazine 1% cream (Thermazene, The Kendall Company, Mansfield, MA) with a bandage to protect the exposed corium. It is the opinion of these authors that topical tetracycline powder, copper sulfate and concentrated forms of iodine commonly used have the potential to cause excessive damage to corium that may restrict or inhibit its future ability to support normal claw horn growth [6]. Exceptions include presence of granulation tissue originating from the corium such as seen in more chronic open lesions. In these cases the use of compounds which may suppress re-growth of granulation tissue after surgical resection may be desirable. The authors have found a mixture of oxytetracycline powder and dexamethasone mixed to a paste or a commercial product containing a mixture of copper, zinc and sulfur (Quickhit™ for dairy cattle, SSI Corp) to be effective in reducing the formation of granulation tissue. Care should be taken to restrict application of the product to the affected area only. Cases should be examined every 7-10 days to monitor progress.

Management of individual thin-soled cows not only depends upon severity of the condition but also stage of lactation, pregnancy status and age. Culling should be considered in cases of non-pregnant older cows, with prolonged lactation and a low milk yield. Cows that are thin-soled on all claws with one or more toe ulcers and abscesses in the sole horn and severely lame irrespective of age, pregnancy or lactation status are considered to have a poor prognosis and culling is recommended based on economic and welfare considerations.

These authors postulated that the primary predisposing factors of the thin soles observed in the herds described here were related to the abrasiveness of the walking surfaces; spilling of sand bedding onto the concrete which may have further increased the abrasiveness; softness of sole horn which was complicated by the near constant exposure of feet to the wet and manure slurry covered flooring conditions. The installation of rubber belting on walkways in Herd 1 resulted in a reduction in the incidence of thin-soled cases from 32.6% for 1st lactation cows to 4% [20] from 1 year

through year 2. Herd 2 had rubber belting in travel lanes and cows had access to dry lots during certain times of the year throughout the observation period, therefore any affects on rate of thin soles could not be determined.

DISCUSSION

The authors have observed that thin-soled cows have a slow painful gait with or without specific leg lameness. The gait may be described as walking tender-footed or as though walking on egg shells. This may also be a feature of acute laminitis. The difference in thin-soled cows is that sole horn becomes soft, thin and flexible resulting in painful weight bearing on affected feet and claws. In addition, laminitis usually affects all four feet whereas the thin sole problem manifests itself more frequently in the outer claw of back feet[18]. The reason for this is that the sole horn of front feet is thicker and contains less moisture compared to back feet[18]. Also, during locomotion cows propel themselves forward with the rear feet whereas the front feet function more or less as supports for the front end. The act of propelling the body forward increases friction and wear on the weight bearing surfaces of the rear feet and particularly the outer claw since this claw normally bears more weight relative to the inner claw.

In thin-soled cows specific leg lameness results primarily from what has been previously referred to as white line disease in the toe region[13]. However, results of the studies presented here demonstrate that the lesion has heretofore been described incorrectly. On closer examination of these lesions we have observed that the initial lesion is actually a separation of the sole from the white line that occurs most commonly in the abaxial (outer) region of the toe near the junction of zones 1 and 2. Since this lesion represents a full thickness break in the epidermis it is by definition an ulcer[10]. The pathogenesis of this lesion is much different than that observed in cases of white line disease or laminitis-induced toe ulcer. These lesions are related to dyskeratotic (poorly

Figure 2. Hemorrhage in the sole adjacent to the white line near the junction of zones 1 and 2 indicating bruising of the underlying corium which becomes apparent immediately preceding the separation of the sole from the white line in this region.

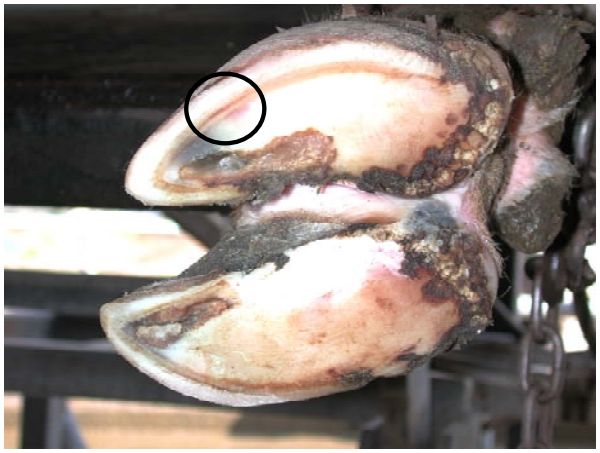

Figure 3. This separation of the sole from the white line can clearly be seen in the abaxial area of zones 1 and 2 (Figure 3 and 4) and was a consistent finding in severely thin-soled cows

or insufficiently keratinized) horn formation within the white line and rotation of the 3rd phalanx that causes compression of the corium in the toe, respectively. On the other hand, thin sole-induced toe ulcer is associated with excessive wear and thinning of the sole that leads to separation of the sole from the inner zone of the white line near the junction of zones 1 and 2 (See Photos 2 and 3).

One of the problems which may result in some confusion and difficulty in making an accurate diagnosis is that the lesion may already be very advanced by the time a trimmer or veterinary practitioner observes it for the first time (See Photo 4). This causes many to incorrectly define these lesions as laminitis-induced toe ulcers/abscesses or white line disease problems and may encourage one to seek correction of a laminitis problem rather than evaluate the abrasiveness of the floor or trimming technique. It is for this reason that it is important to understand the pathogenesis of this lesion.

Separation and fragmentation of the sole in abaxial area of zone 5 adjacent to zones 1 and 2 in severely thin-soled cows has been reported before [19] and was observed by the authors to be a consistent lesion not only in the 2 herds described here, but also in other herds. Based on the nature of the lesion and its anatomical location the authors have proposed that the lesion be termed a “thin-sole induced toe ulcer” (TSTU). The term “toe ulcer” has traditionally been used in relation to laminitis where downward displacement of the apex of the third phalanx causes pressure necrosis of the corium in the toe region with toe ulceration as a consequence [9]. The term toe abscess is often applied to this lesion and often presented as a primary diagnosis. However, as indicated here the precise cause of toe lesions needs to be determined so that appropriate control measures are implemented.

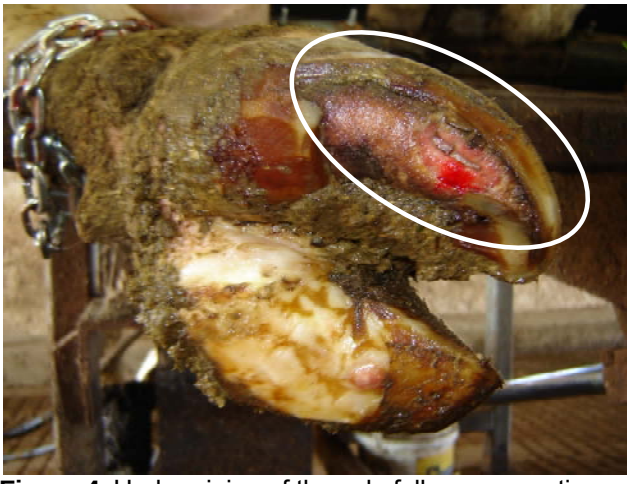

Figure 4. Undermining of the sole follows separation with abscessation and damage to the exposed corium in the region of the toe (toe abscess).

Corkscrew Claw (otherwise known as Screw Claw)

Corkscrew claw also predisposes to toe ulcers/abscesses, but the pathogenesis is distinctly different. An abnormality between the 2nd and 3rd phalanx (P3) causes an outer to inner twist of the claw that causes the outer wall to roll under the sole whereby it becomes part of the weight bearing surface. Similarly, the inner wall at the toe rotates or twists inward and upward causing the inside wall to become repositioned dorsally while the sole at the toe faces inward rather than downward toward the weight bearing surface. Internally, the P3 bone and corium of the claw rotate in similar fashion. This causes the corium to be in abnormally close proximity to the weight bearing surface in zones 1 and 2. Since this claw is also normally larger and overgrown, the normal claw

will often be atrophied (smaller). In the most severe cases of corkscrew claw the non-affected claw is nearly non-weight bearing.

Toe lesions in corkscrew claws develop in 2 ways: 1) white line separation in zones 1 and 2, and 2) as the inner wall twists and repositions itself dorsally, it also becomes folded over on itself trapping organic matter within the fold. This is a near perfect environment for anaerobic bacteria that eventually cause further necrosis and abscess formation that ultimately exhibits itself as a toe abscess. Most toe lesions in cattle with corkscrew claws occur by 1 or the other of these ways. Careful examination of the lesion and the presence of corkscrew claw helps one discern the possibilities of this condition as a predisposing cause of toe abscesses.

Trauma-Related Lesions of the Toe

Cattle working facilities, certain types of flooring conditions and sometimes rough or careless animal handling contribute to an increased risk of trauma-related lesions of the toe. These are normally a little more common in feedlot cattle or younger animals that may be less accustomed to human contact and handling. Fractures of the claw capsule, and on occasion P3, may lead to very severe lameness and complications such as the formation of a sequestrum (a piece of bone devoid of blood supply). A sequestrum occurs most commonly when injury results in a fracture of the P3 bone with subsequent loss of blood supply to the portion of bone that becomes displaced as a result. Without a blood supply the tissue (in this case – bone) dies and becomes a sequestrum. The body will naturally attempt to eliminate this dead bone material. It is not uncommon to find a loose necrotic piece of bone in chronic toe lesions. In many cases, removal of this necrotic bone will permit complete healing.

CONCLUSION

There are at least 5 conditions that may predispose to toe lesions in cattle. These include: toe ulcer, white line disease, thin sole toe ulcer (TSTU), corkscrew claw and trauma-related lesions affecting the apex of the claw. Of these, one of the most common by far in the southeastern United States is TSTU. Thin sole-induced toe ulcer should be distinguished from toe ulcers and white line disease, both of which are associated with laminitis as an underlying cause. Toe abscess is a complicated lesion and should not be presented as a primary lesion as it usually follows on thin sole-induced toe ulcer, laminitis-induced toe ulcer, white line disease or possibly foreign body penetration of the sole. Corkscrew claw and traumatic toe lesions are also common causes of toe problems and should be distinguished from other causes of toe abscess. Correct lesion identification, cause and recording are important for appropriate lameness prevention strategies in large dairy herds. Toe ulcer in combination with other changes such as a short dorsal wall (toe) and a flexible sole will strongly suggest that factors predisposing to excessive horn removal/wear needs to be investigated.

REFERENCES

1. AABP Lameness Committee. An Update on white line disease AABP Fact Sheet. 2006.
2. Barnes MM: Update on dairy cow housing with particular reference to flooring. *Br Vet J.* 145 (5): 436-445, 1989

3. Budras KD, Habil Dr, Mulling Ch, Horowitz: A. Rate of keratinization of the wall segment of the hoof and its relation to width and structure of the zona alba (white line) with respect to claw disease in cattle. *AJVR* 57(4): 444-4551, 1996.
4. Cermak J: Design of slip-resistant surfaces for dairy cattle buildings. *Bovine Pract* 23: 76-78, 1998
5. De Belie N, Rombaut E: Characterisation of Claw-floor Contact Pressures for Standing Cattle and the Dependency on Concrete Roughness. *Biosystems Engineering* 85 (3): 339-346, 2003.
6. Kempson SA, Langridge A, Jones JA: Slurry, Formalin and Copper Sulfate: The effect on claw horn. *Proceedings of the 10th International Symposium on Lameness in Ruminants,* Lucerne, Switzerland: 216-217, 1998
7. Mulling Ch, Budras KD: Influence of environmental factors on horn quality of the bovine hoof . *Proceedings of the 10th International Symposium on Lameness in Ruminants,* Lucerne, Switzerland: 214-215, 1998
8. Mulling Ch KW: Theories on the pathogenesis of white line disease-an anatomical perspective. *Proceedings of the 12th International Symposium on Lameness in Ruminants*, January 9-13, Orlando, Florida: 90-98, 2002.
9. Ossent P, Lischer C: Bovine laminitis: the lesions and their pathogenesis. *In Practice.* September 1998: 415-427.
10. Oxford concise Medical Dictionary. Fourth Edition. Oxford University Press, Walton street, Oxford ox2 6dp: 684, 1994
11. Paulus N, Nuss K: Claw measures at defined sole thickness. *Proceedings of the 12th International Symposium on Lameness in Ruminants*, January 9-13, Orlando, Florida: 428-430, 2002.
12. Shearer JK, van Amstel SR: Effect of Flooring and/or Flooring Surfaces on Lameness Disorders in Dairy Cattle. *Proceedings of the Western Dairy Management Conference.* Reno, Nevada, March 7-9: 149-159, 2007
13. Shearer JK van Amstel SR, Benzaquen M, Shearer LC: Effect of Season on Claw Disorders (including Thin Soles) in a Large Dairy in the Southeastern Region of the USA. *Proceedings of the14th International Symposium on Lameness in Ruminants*, Colonia, Uruguay, November 7-11: 110-111, 2006.
14. Thompson PN: Osteitis of the apex of the third phalanx following foot trimming in a dairy cow. Jnl of the S Afr Vet Assoc. 69 (1): 23-26, 1998.
15. Toussaint Raven E: Trimming. In *Cattle Foot Care and Claw Trimming*. Chapter 3: 75-106, 1989.
16. Valentino LW, St.Jean G, Anderson DE, Desrochers A, Kersting K, Lopez M, Adams SB, Huhn J, Mueller EPO, Cohen ND: Osseous sequestration in cattle: 110 cases (1987-1997). JAVMA 217 (3): 376-383, 2000
17. van Amstel SR, Palin FL, Shearer JK, Robinson BF: Anatomical Measurement of Sole Thickness in Cattle following Application of Two Different Trimming Techniques *Bovine Pract* 36 (2): 136-140, 2002
18. van Amstel SR, Shearer JK, Palin FL: Moisture Content, Thickness, and Lesions of Sole Horn Associated with Thin Soles in Dairy Cattle. *J. Dairy Sci*., 87:757-763, 2004.
19. van Amstel SR, Palin FL, Shearer JK: Measurement of the thickness of the corium and subcutaneous tissue of the hind claws of dairy cattle by ultrasound. *Veterinary Record* 155: 630-633, 2004
20. van Amstel SR, Shearer JK, Palin FL, Cooper J, Rogers GW: The effect of Parity, Days in Milk, Season,and Walking Surfaceon Thin Soles in Dairy Cattle. *Proceedings of the14th International Symposium on Lameness in Ruminants*, Colonia, Uruguay, November 7-11: 142-143, 2006.

21. van Amstel SR, Shearer JK: *Manual for Treatment and Control of Lameness in Cattle.*. Blackwell Publishing Professional, Ames, Iowa: 59-62, 2006.
22. Van der Tol PP, Metz JH, Noordhuizen-Stassen EN, Back W, Braam CR, Weijs WA: The vertical ground reaction force and the pressure distribution on the claws of dairy cows while walking on a flat substrate, *J Dairy Sci.,* 86 (9): 2875-83, 2003.
23. Van der Tol , Metz JHM, Noordhuizen-Stassen EN, Back W, Braam CR, Weijs WA: Pressure distribution on the bovine claw while standing, *Proceedings of the 12th International Symposium on Lameness in Ruminants*, Orlando Florida: 202-205, 2002.