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Pathomorphological Findings of White Line Disease with Digital and Inner Organ Infections in Culling Dairy Cows

[1]Mohsen Nouri, [1]Iradj Nowrouzian,
[2]Seyyed Hossein Marjanmehr, [1]Alireza Vajhi and [1]Davoud Faskhoudi

[1]Department of Clinical Sciences,
[2]Department of Pathology,
Faculty of Veterinary Medicine, The University of Tehran, P.O. Box 14195-181, Tehran, Iran

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ABSTRACT

The aim of this study was to investigate pathomorphological findings of white line disease in culling lame cows, with special reference to the lesions and their distribution. The most prominent pathomorphologic findings of the claw with white line disease included extensor process entheseophyte (75.0%), flexor tuberisity entheseophyte (37.5%) and abaxial margin bone absorption (68.7%). Six out of the total of WLD3 cases had osteolysis of flexor tuberisity (66.7%). In WLD3 cases, three out of the total of 9 cases showed septic osteoarthritis in distal inter-phalangeal joint (33.3%). Ankylosis was observed only in one case between P3 bone and distal sesamoid bone. One of case with WLD2 showed severe bone sequestration of P3 bone. Laminitis may have affected virtually this case at some previous time. Routine trimming and scoring of locomotion seems to provide suitable parameters for early diagnosis and prevention of premature culling in dairy cows.

Keywords: Lameness, Laminitis, Deep Sepsis, White Line Disease, P3 Bone

1. INTRODUCTION

White Line Disease (WLD) is a commonly observed lesion and has frequently been reported as a major cause of lameness, particularly where cattle are housed, fed concentrates and higher yielding (Collick *et al*., 1997; Amory *et al*., 2008; Kujala *et al*., 2010). Economic losses associated with this lesion include decreased milk production, weight loss, reduced fertility, treatment costs and premature culling (Collick *et al*., 1997; Green *et al*., 2002; Hashemi *et al*., 2005; Amory *et al*., 2008; Nouri *et al*., 2008a).

In general, the term white line disease refers to the conditions of haemorrhage, fissure and abscess, which may occur at the white line zone, usually the outer claw of the hind foot (often both) is usually involved (Greenough, 2007). Bacterial WL phlegmon renders cows lame and poses a marked problem in dairy herds in Iran. In addition, nearly all haemorrhages are indicators of subclinical laminitis, although they are supposed to have different origin in the WL and sole areas (Mulling, 2002; Lischer *et al*., 2002; Offer *et al*., 2003). Weakening of the WL and disturbances in horn production caused by laminitis (haemorrhages) have been suggested to underlie WLD, although WLD might also present as a primary disease (Mulling, 2002). Several Iran reports cite the condition as responsible for between 1.53 and 27.14% of lameness (Meimandi-Parizi and Eskandari, 1996; Mansouri-Nejad *et al*., 2011; Nouri *et al*., 2011). Other studies also have reported the disease between 5.5 and 39.0% (Eddy and Scott, 1980; Choquetta-Levy *et al*., 1985; Tranter and Morris, 1991; Collick *et al*., 1997; Hedges *et al*., 2001; Manske *et al*., 2002; Sogstad *et al*., 2005; Kujala *et al*., 2010).

Corresponding Author: Mohsen Nouri, Department of Clinical Sciences, Faculty of Veterinary Medicine, The University of Tehran, P.O. Box 14195-181, Tehran, Iran Tel: + 982188066331 Fax: 66933222

Although laminitis is generally regarded as the primary cause for the pathological changes within the white line region of the sole, other contributing factors should be considered. In this study, emphasis will be placed on the more advanced condition of white line abscess. The aim of this study was to investigate and quantitate pathomorphological findings of white line disease in culling lame cows, with special reference to the lesions and their distribution.

2. MATERIALS AND METHODS

2.1. Animals

This cross-sectional and descriptive study was carried out in the winter of the year 2010 at an abattoir in the vicinity of Tehran (Meysam, Robatkarim). During the three- month period of investigation, 53 culled lame cows of 1135 culled Holstein cows having digit disorders were randomly selected for clinical and pathomorphological purpose. The owners were interviewed using a questionnaire to record information about culled lame cow. All cases aged three to eight years.

Lameness was assessed by means of a visual locomotion score (1-5). Each animal was observed standing and walking (on a concrete surface whenever possible) by an experienced technician. Both front legs and hind legs were amputated at the carpus and the tarsus, respectively, immediately after slaughter.

2.2. Radiographic Examination

The claws and interdigital space cleaned thoroughly with water and a brush before radiography to be able to exactly diagnose the kind of injury in the radiographic images. An x-ray machine was used in this study (Toshiba, model DC-12M) to take radiographic images. In every case at least two radiographs of lateromedial or mediolateral and dorsopalmar/dorsoplantar, were taken using exposure factors of 25 mA, 85-95 KV in 0.04 or 0.02 sec. Radiographs were recorded by the mammography cassettes in sizes of 18×24 and 24×30.

2.3. Pathologic Examination

For availability and study of the probable changes in soft tissues, the skin of digit was dissected in each sample by a scalpel. The bones were taken away from the joints by the scalpel in order to be naked. Through the method of putrefaction (bacterial maceration and bleaching), the bones were put in a special dish (a plastic cover). In this regard, some plastic dishes with sufficient water were used and placed near the heater. The bones were in the water for at least 72 h and this action repeated again after changing the old water. Thus, all the soft tissues were taken away from the bones. All the samples were disinfected by diluted disinfectant (Vaytex®) for 30 minutes and the existing tiny tendons and ligaments beside the new bones were taken away slowly and delicately by the scalpel. Then, the bones became dried in free air and prepared for the pathological study. Finally, the findings were discussed descriptively.

3. RESULTS

3.1. Clinical Findings

Sixteen cases out of the total of 53 cases (30.1%) were affected by WL lesions; 7 cases (13.2%) and 9 cases (16.9%) were affected with WLD 2 and WLD 3, respectively. The prevalence rate of WL lesion in the hind limb (75.0%) was higher than fore limb. Affected cows were lost their weight significantly and preferred to lie. The animals were severely lame and presented with disability in weight bearing. Locomotion scoring assessment (1-5) of the case showed score 5 (of 5 = non-weight bearing) lameness.

The affected limb associated with a painful, firm and focal inflammatory swelling of the bulb heel (**Fig. 1**) and periople part was distended. The affected claws were more boxy than normal and the abaxial wall was convex in all directions. The opening of the claws was asymmetric. In some cases, the region proximal to the dorsal coronary band was erythematous. Some cases showed widening of the axial and abaxial laminar zone. In all cases, the horn of the WL zone was lost and result to be established of oval or circular perforation. Eight cases have been trimmed incorrectly and other had no natural wearing on the solar surface and showed an increase in thickness of the keratinized tissues.

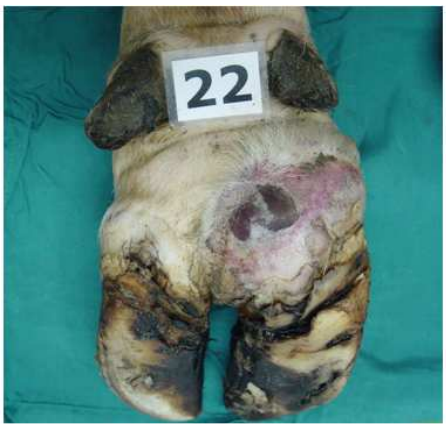

Fig. 1. The heel bulb on the lateral digit is wider than the medial digit. This sign in the involved digital were the permanent features of the culled lame cows with deep sepsis of digit bones

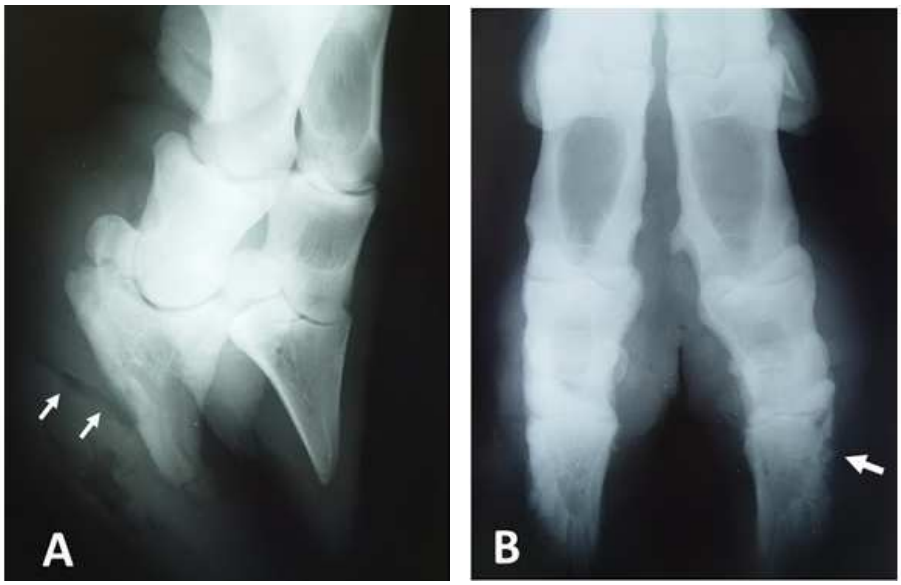

Fig. 2. (A) Dorsolateral-plantomedial oblique view of abaxial margin bone absorption is seen on the abaxial wall of P3 bone (white arrow). Gas density (white arrows) into the claw is present. (B) Dorsoplantar view of the affected digit by WLD2 showing osteo

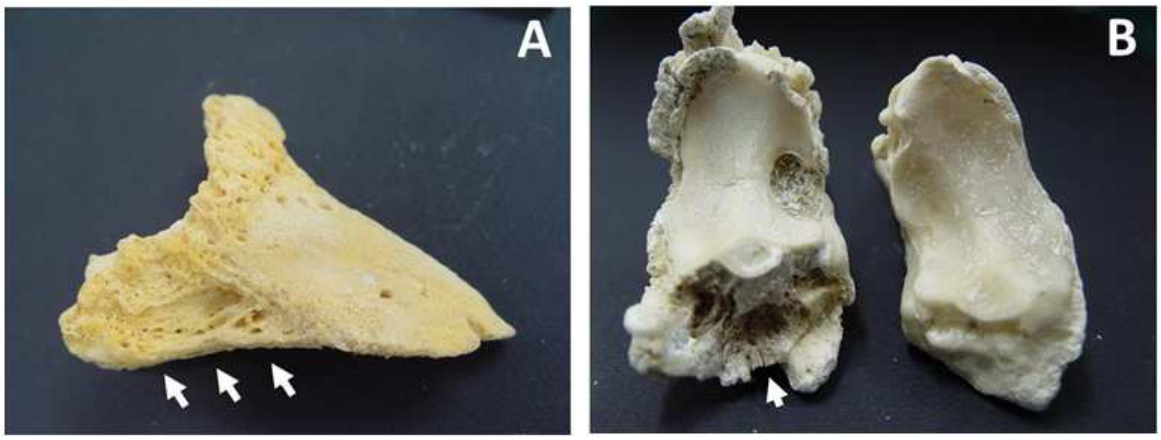

Fig. 3. (A) Lateral view of the affected digit by WLD2 showing osteomyelitis on the abaxial wall of P3 bone (white arrows). (B) Caudal view of the affected digit by WLD3 showing osteolysis of flexor tuberisity of P3 bone (white arrow)

3.2. Radiographic Findings

Radiographic signs such as soft tissue swelling, new bone formation, osteitis and gas density were distributed in different sizes; they were more significant considering the increased infection and the involvement of other neighboring structures, such as coffin's joint and the adjoining digit bones. Radiological examinations showed chronic lesions of WLD were accompanied by alterations in the anatomical structure of third phalanx such as abaxial margin bone absorption, flexor tuberisity entheseophyte, extensor process entheseophyte and widened vascular channel (**Fig. 2**).

3.3. Pathologic Findings

The necropsy procedure revealed tendovaginitis and the consistent purulent discharge was confined to the digital region. Affected digits of the culled lame cows with WLD depicted a quite wide range of pathologic

signs. The naked bone showed considerable bone changes such as excessive new bone formation, osteolysis, ankylosis and sequestration; Eleven out of the total of WLD cases showed abaxial margin bone absorption (68.7%) and also 6 out of the total of WLD3 cases had osteolysis of flexor tuberisity (66.7%) (**Fig. 3A and B**). In WLD3 cases, three out of the total of 9 cases showed septic osteoarthritis in distal inter-phalangeal joint (33.3%). In most cases chronic osteophytes of extensor tendon was seen at insertion on the extensor process (75.0%), but only three cases (37.5%) showed calcification of the deep flexor tendon on P3 bone. Ankylosis was observed only in one case between P3 bone and distal sesamoid bone. One of case with WLD2 showed severe bone sequestration of P3 bone. Four mild cases (25.0%) were concurrent lesion for contralateral claw.

4. DISCUSSION

The pathogenesis of white line disease has never been demonstrated conclusively (Greenough, 2007). It is postulated that there are two possible pathologies: A lesion caused by external trauma (The open hypothesis) and another one caused as the result of the collapse of the pedal bone support system and this could result in lateral pressure on the abaxial wall. In this way the white line could be torn open from the inside (The closed hypothesis) (Greenough, 2007). Breed, parity, housing type, hard surfaces, soft horn as a result of wet conditions, claw deformities, age, milk yield, routine claw trimming, chronic laminitis and excessive road work all have been associated with white line disease (Collick *et al*., 1997; Hedges *et al*., 2001; Green *et al*., 2002; Manske *et al*., 2002; Livesey *et al*., 2003; Potzsch *et al*., 2003; Hultgren *et al*., 2004; Tomlinson *et al*., 2004; Sogstad *et al*., 2005; Greenough, 2007; Amory *et al*., 2008; Kujala *et al*., 2010).

Most white line disease cases were located in the posterior part of the outer wall of the lateral hind claw (Zone 3). The abaxial border of the sole is the area of first impact in locomotion (Edwards, 1980). The WL is anatomically susceptible (weak laminae region (especially in zone 3) and different horn production in different parts of WL) to mechanical disturbances, which could explain the deleterious association of the slats (Mulling, 2002; Sogstad *et al*., 2005; Kujala *et al*., 2010).

Widening of the periople (Nouri *et al*., 2008b) and swelling of the heel area (Van Meter *et al*., 2005; Nouri *et al*., 2008b; Collick *et al*., 1997; Greenough, 2007) occurs when a deep sepsis of digital bones is present. These cases showed both of signs.

In most cases chronic osteophytes of extensor tendon was seen at insertion on the extensor process, but only three cases (37.5%) showed calcification of the deep flexor tendon on P3 bone. Abnormal weight bearing and claw conformation effect on the excessive traction on the tendon. Hashemi *et al.* (2005) studied the radiographic appearance of lame cows with signs of white line disease. The most prominent radiographic abnormalities of the claw artery included vascular dilations (90%), extensor process entheseophyte (80%), flexor tuberisity entheseophyte (40%) and solar margin bone absorption (45%). Mansouri-Nejad *et al.* (2011) found sub-solar abscess in zone 3 progressed to the septic osteitis of the third phalanx with osseous sequestration in 14.2 % cases.

Pedal osteolysis was found on the abaxial wall of P3 bone of the affected claw with WLD2. This sign is due to the persistence of the external lesion (Moldovan *et al*., 1990). Once the corium of the WLD2 was exposed, infection to penetrate in the white line and drove upwards to cause a septic laminitis (Edwards, 1980). The infection track upwards, eventually ending in pedal osteolysis on the abaxial wall of P3 bone and flexor tuberisity. The osteolysis and pedal osteitis in the region of the laminae at the dorsal edge of P3 bone are considered signs of laminitis (Bargai, 1989). In grosspathologic study of naked bone, pedal osteolysis was found on the abaxial margin of the P3 bone. However, other radiographic studies have reported pedal osteolysis on the solar margin bone (Gantke *et al*., 1998; Hashemi *et al*., 2005).

Infection of the Distal Interphalangeal Joint (DIJ) usually results from localised purulent processes that spread to the deeper structures of the claw, such as White Line Disease (WLD) (Heppelmann *et al*., 2009). In the majority of cases with infection of the DIJ, other adjacent anatomical structures, including the Deep Digital Flexor (DDF) tendon, the podotrochlear bursa and the flexor tendon sheath are affected as well as the distal sesamoid bone and the middle (P2) and distal Phalanges (P3), which form the joint (Heppelmann *et al*., 2009). In our study, 33.3% out of the total of WLD3 cases showed septic osteoarthritis in distal inter-phalangeal joint.

Involvement of the tendon is uncommon in WLD cases (Collick *et al*., 1997). Advanced cases had tendon involvement in this study. In these cases, sepsis of the digital flexor tendon sheath (septic tendovaginitis) occurred as a result of extension of local sepsis.

Improper hoof trimming techniques may result in traumatic laminitis (Enevoldsen and Grohn, 1991); at least

if the trimmer takes away supportive mechanism of the horn with a grinder or the sole becomes too thin during trimming (Kujala *et al*., 2010). This case showed increase of solar layer without any sign of trimming. Trimming therefore could not be responsible for WLD in our study.

In this study clinical lameness was observed and managed by the farmer. It is likely, given previous research that indicated that farmers did not detect all cases of lameness (Whay *et al*., 2002), that some cows were treated inappropriately and so no diagnosis and or misdiagnosis were made (Amory *et al*., 2008; Nouri *et al*., 2008a). There were certainly some lame cows on the farm at routine visits assessing locomotion (Barker *et al*., 2007).

5. CONCLUSION

The results of the present study indicate that laminitis may have affected virtually this case at some previous time. Routine trimming and scoring of locomotion seems to provide suitable parameters for early diagnosis and prevention of premature culling in dairy cows.

6. ACKNOWLEDGMENT

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