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## APPLICATION OF FUNCTIONAL TRIMMING PROCEDURES TO CORKSCREW CLAWS

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Corkscrew claw is a heritable misalignment of the phalanges within the digit.<sup>1</sup> The dorsoplantar plane of the distal interphalangeal joint may be rotated by 11° from normal (See Figure 1a).

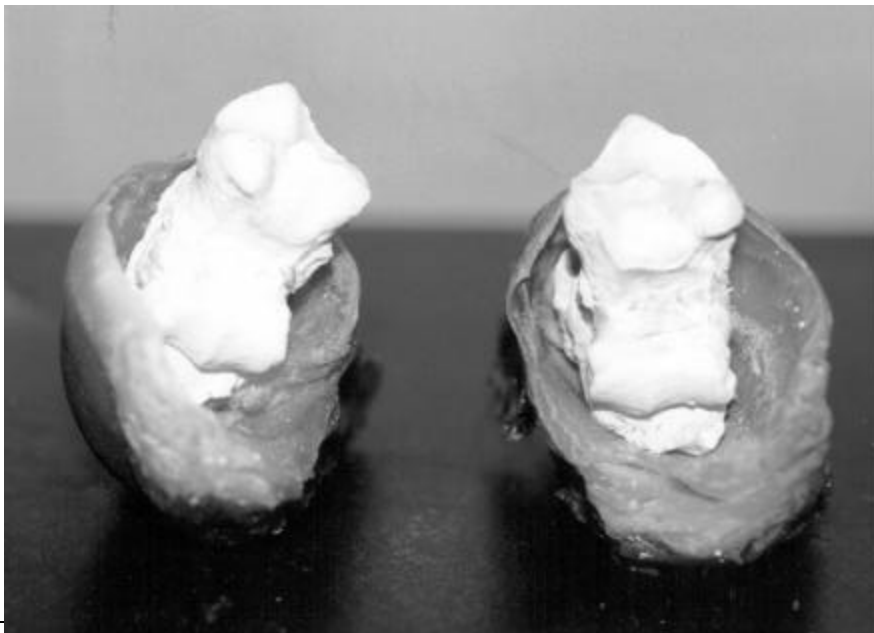


Figure 1a. Note the abnormal angulations of the 2<sup>nd</sup> or 3<sup>rd</sup> phalanges of the screw claw (left) compared with the normal (right).

The third phalanx may be abnormally long and thin (See Figure 1b).<sup>8</sup> The bone may also have an abaxial curvature making it lean towards the outside. A deep groove develops on the inside of the claw capsule in the region of the abaxial white line (See Figure 2 a, b). This groove may potentially result in less available thickness of the sole and white line horn. The consequence of this abnormality is that trimming of the sole in this region often leads to accidental exposure or damage of the solar corium.



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Figure 1b. Note the elongated and curved shape of the abnormal (screw claw) P3 on the right.



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Figure 2a. Note groove in the region of the abaxial white line.



Figure 2b. Note the presence of a groove in the abaxial white line of the screw claw (right) as compared to the normal claw (left).

A palpable periarticular exostosis forms at the level of the abaxial coronary band.<sup>1</sup> This may exert pressure on the abaxial dermis resulting in accelerated horn growth.<sup>1</sup> Growth rates of the mid and caudal wall were faster in cattle with corkscrew claw as compared to those with normal conformation of the claw capsule.<sup>6</sup> Increased vascularity of the third phalanx of the screw claw has been demonstrated angiographically.<sup>5</sup> This increase vascularity appeared to have been generalized and not only concentrated along the abaxial margin.

The heritability estimate (score) for screw claw is low (0.05) indicating that other factors such as claw disease, inappropriate claw care, nutrition and management may play a more important role in the condition.<sup>2</sup> Corkscrew claw is observed most commonly in the lateral claws of the hind leg in cattle older than 3.5 years of age.<sup>1, 3</sup> The incidence of the condition may vary from 3-4% to 18.2%.<sup>1,4</sup>

Corkscrew claw may predispose to lameness due to overgrowth and increased weight bearing. Lesions within the horn capsule that are commonly observed include hemorrhage of the sole and white line, white line separation and sole ulcers (SR van Amstel, unpublished data). White line separation occurs commonly at the abaxial heel sole junction or at the toe. Other abnormal conditions affecting the claws, which may resemble corkscrew claw, include slipper foot, scissor claw and rotation of the medial claw in heifers.<sup>7</sup>

Corkscrew claw is characterized by the following abnormalities in claw conformation and growth:

1. Abaxial to axial displacement of the wall. The mid and caudal areas of the abaxial wall curve ventrally and can become part of the bearing surface of the claw (See Figure 3).



Figure 3.

2. Axial displacement of the sole and axial white line (See Figure 4).



Figure 4.

3. Rotation of the toe. The toe and axial bearing surface becomes non-weight bearing. The sole and white line at the toe may be perpendicular to the weight-bearing surface (See Figure 5).



Figure 5.

4. The axial wall becomes displaced and a fold may develop in the axial wall (See Figure 6).



Figure 6. Note the fold in the axial wall.

5. In some cases, a palpable exostosis develops at the skin horn junction at the level of the abaxial coronary band.
6. The screw claw becomes overgrown compared to the inside claw particularly at the heel and axial heel sole junction (See Figure 3).

In some instances the inside claw may become virtually non-weight bearing and appears to undergo disuse atrophy (SR van Amstel - personal observation). In such instances the medial claw appears smaller, the sole appears sunken with a very marked slope towards the interdigital space and the abaxial wall has a sharp edge with little or no sign of wear. The height difference between the lateral (screw claw) and medial claw is marked particularly at the heel (See Figure 7).



Figure 7.

Corrective trimming of the corkscrew claw may present a challenge particularly with regards to regaining balance between the two claws. The height difference between the two claws should be corrected, taking into account that anatomical abnormalities associated with screw claw, may complicate this objective.<sup>1</sup>

To investigate sole thickness of corkscrew claw following trimming, six cadaver legs with corkscrew claw, obtained from a packing plant, were trimmed according to the Dutch method.<sup>9</sup> Using a band saw the corkscrew claws were then cut in cross section 1.25" back from the toe. Sole thickness was measured at the abaxial white line. The results so obtained were compared to the sole thickness of 66 normal claws, trimmed using the same method. Results are shown in Table 1. Results show that there was a highly significant difference (less than .001) in the sole thickness of the trimmed screw claw group versus the trimmed normal group. For the screw claw group, sole thickness ranged between 1-8 mm with a mean of 4.33 mm whereas for the normal group the sole thickness range was 4-15 mm with a mean of 8.24 mm.

If a sole thickness of 5 mm is taken as a standard,<sup>9</sup> then 66.7% of the screw claw group has a sole thickness of less than 5 mm whereas only 1.5% of the trimmed normal group was less than 5 mm.

**Table 1. Sole thickness of trimmed corkscrew and normal claws.**

	Corkscrew	Normal
Number	6	66
Standard deviation	2.42	2.49
Minimum sole thickness	1 mm	4 mm
Maximum sole thickness	8 mm	15 mm
Mean	4.33 mm	8.24 mm
% Less than 5 mm sole thickness	66.7%	1.5%

Suggested corrective trimming procedure for corkscrew claw.

Normal claw:

- \* The toe length of the medial claw is reduced to 3 inches (7.5 cm) in length.

Corkscrew claw:

- \* The toe length of the screw claw is reduced to the same length as that of the normal claw (See Figure 8a).



Figure 8a. Normal and screw claw toe length reduced to 3" (7.5 cm).

- \* The upward deviation and rotation of the dorsal wall is removed (straightened) in order to align it with the dorsal wall of the normal claw (See Figure 8b and 9). Full wall thickness may sometimes be penetrated during this procedure resulting in hemorrhage.

Further horn removal should then be terminated. Over thinning of the dorsal wall in a small confined area usually does not result in any complications.

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Figure 8b. Straightened dorsal wall of corkscrew claw.



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Figure 9. Straightened dorsal wall of the corkscrew claw. The axial curve at the toe and fold in the axial wall (Figure 6) had been removed.

\* Balance both the toe and the heel of the screw claw with that of its opposite claw. Be aware that the corkscrew claw always has a higher heel; do not lower the heel of the

opposite claw. The wall is often very hard and using hoof nippers or an angle grinder can facilitate trimming.

\* Note that the sole of the corkscrew claw, particularly on the abaxial side near the white line, can easily be over trimmed and made too thin (See Table 1).

\* Slope the sole of the corkscrew claw at the interdigital space. During this procedure, the fold in the axial wall is removed (See Figure 6 and 9) as well as the axial curve at the toe. The trimmed corkscrew claw will often have a narrow shape (See Figure 9) with a smaller and narrower weight-bearing surface.

\* If the corkscrew claw is severely overgrown, the inside claw should not be trimmed. Start by trimming the corkscrew claw first as described, until it is balanced with the normal claw. If enough sole horn thickness remains, both claws can now be further trimmed. Sole horn thickness can be evaluated by measuring toe thickness after the dorsal wall length has been reduced to 3 inches (7.5 cm). Sole depth can be reduced to 0.25-inch thickness at the toe.<sup>9</sup> If the corkscrew claw cannot be balanced with the normal claw, application of a claw block to the normal claw may be helpful for the following reasons:

\* Removal of weight bearing from the corkscrew claw may facilitate healing of sermal and epidermal lesions.

\* Increase weight bearing by the normal claw may stimulate horn growth in the claw.

\* Corkscrew claws should be trimmed at 3-4 months intervals.

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## FIELD PROCEDURES FOR TREATMENT AND MANAGEMENT OF DEEP DIGITAL SEPSIS

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### Introduction

There are many cases in which the hoof trimming of a lame cow is concluded with the curettage of a corium chronic lesion or the removal of a proliferative digital dermatitis. This kind of surgery doesn't need any particular stratagem; systemic antibiotic therapy is not necessary and the cow can also suddenly be sent in the herd, with only a bandage and/or a block under the healthy claw. Bovine digital lesions dealing with surgery can be divided in lesions of skin and sub skin tissues (proliferative digital dermatitis, interdigital hyperplasia, bulbar abscess and haematoma, neoplasm, wounds), claw capsule and corium (exungulation, pododermatitis septica cronica, fibropapillomas), deep structures (phalanx osteitis, septic arthritis of distal and proximal interphalangeal joints, septic arthritis of fetlock joint, septic tenosynovitis, digit luxation, bone sequestra, retroarticular abscess, navicular bursa and navicular bone infection, phalanxes fractures). Among these, deep digital infections are the most important because are expensive, difficult to cure usually compromise current lactation and are a cause of culling: in this paper only some aspects will be treated, referring to bibliography for further indispensable investigations. The first sign that make us suspect deep structures involvement, in addition to the severe lameness, is unilateral swelling of the distal part of the limb. Within few days, bovine health condition worsened with temperature, leaning to recumbence, anorexia, loss of weight and drop in milk production. These usually originate from primitive corium lesions (sole ulcer, white line disease, puncture wounds) or from interdigital space lesions (interdigital phlegmon) that, neglected or improperly treated or, sometimes, already deep in the beginning (e.g. severe peracute int. phlegmon), open the route to the infection of the underlying structures. Less frequently they can be caused by trauma or puncture wounds.

### Deep Digital Sepsis Therapy

Digital amputation is the most used surgical therapy because it's a cheap operation that permits a quick return to production, with rare complications and few post surgical cares. Farmers usually don't like to have in the stall an amputated cow and so, often, they have recourse to emergency slaughter; moreover mean survival time for these animals goes from 18 to 24 months<sup>1</sup>. Different amputation techniques exist, depending on infection diffusion and on surgeon preference. Both disarticulation and proper amputation, performed at different levels, give good results; skin flap preservation, when it is allowed by lesion location, can anticipate the healing if infected tissues are completely removed and secondary contamination don't occur. To better protect the stump it can be useful to apply a wooden block under the healthy claw, especially if environmental conditions are poor or in strawyard stalls. A seven days general antibiotic therapy is usually sufficient. To confine the cow from 10 to 15 days it's always advisable. The increasing of high genealogy animals in an always growing number of farms and a higher availability of knowledge about conservative surgical techniques of the claw, wide the number of therapeutic options available to bovine practitioner: the aim is to maintain the cow in the farm for all her productive

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life. Deep lesions most frequent are: osteitis of the 3<sup>d</sup> phalanx, retroarticular abscess, septic arthritis of the distal interphalangeal (DIP) joint, retroarticular structures infection (navicular bone and bursa infection, deep flexor tendon avulsion), septic tenosynovitis. In literature both clinical picture both treatment ways are well described.

The DIP joint can be dealt with a horizontal palmar / plantar approach: a transversal incision of about 180° is made from the axial to the abaxial aspect of the bulb; a wedge of tissue and deep flexor tendon (DDFT) end are removed; overextending the digit it is possible to remove navicular bone, and DIP joint can be entered<sup>4,8</sup>. K: Nuss & M.P. Weaver<sup>10</sup> describe a "vertical" palmar / plantar approach, in which DDFT is isolated with an incision beginning 2 cm below the dewclaws down to solear surface; with an elliptical incision is then removed the fistulous tract and the eventually starting lesion. Once the navicular bone has been removed the DIP joint is reached. In case of septic arthritis this route can be used to perform arthrodesis or joint resection, to encourage ankylosis developing between second and third phalanx, eliminating pain and restoring normal weight bearing. When anatomical lesions are extended or surgery is delayed, longer 14 days from septic arthritis diagnosis, digit amputation is advisable<sup>8</sup>. In case of retroarticular abscess an axial / abaxial approach is described with drainage insertion and repeated flushing<sup>4,8</sup>. When septic arthritis occurs without retroarticular structures involvement, different approaches are possible to preserve them. Axial / abaxial approach: a channel is drilled from abaxial to axial wall, through the DIP joint. The articular space is curettaged and a tubular drainage is inserted: four days flushing are made with 20 l/day of saline<sup>4,8</sup>. Abaxial approach: a horizontal abaxial wall fenestration is performed (15-x 40 mm); after an accurate articular curettage and flushing gentamycin-impregnated collagen sponges (GICS) are inserted<sup>13</sup>. Dorsal approach: two arthrostomies with Michel's trephine are executed in correspondence of the dorsal pouch, through which curettage and flushing are performed for one week at least<sup>3</sup>.

The techniques providing for long post surgical cares (e.g. articular lavage for many days) and repeated clinical visits, even if effective, in field conditions are difficult to apply. The use of GICS has drastically reduced, according to the authors, the need of post surgical cares, but today they are very expensive. During the infection of deep digital flexor tendon (DDFT), superficial digital flexor tendon (SDFT) and their sheath (FTS) a targeted therapy includes different options: 1) medical therapy; 2) limited tenovagotomy and lavage; 3) tenovagotomy with tendon debridement associated or not to an indwelling lavage system; 4) DDFT resection 5) Radical resection of DDFT, SDFT and FTS<sup>1,3,12</sup>. In case of severe tendons infection or necrosis radical resection is surely recommended.

Pedal bone osteitis therapy varies according to which part of the bone is affected and to the process extension. When the apex is infected, tip claw resection is indicated; if the plantar side or tuberculum flexorium are affected a curettage up to the healthy bleeding bone is usually carried out. Digital amputation is used in extended 3<sup>rd</sup> phalanx infections.

### **Considerations on Field Surgery Procedures**

The case history, the digital swelling features and clinical exam are often sufficient to issue a diagnosis. Sometimes this is expressed during surgery (e.g. navicular bone infection). Radiological exams can help to confirm clinical diagnosis, to estimate bone lesions magnitude addressing to a more targeted therapy. In the buiatric practice it's not used very much because

sometimes is considered unnecessary and an extra source of expenses for the farmer. It is essential in lameness cases with non-swollen claws (e.g. pedal bone fractures)<sup>2</sup>. Performing a surgical operation, on tendons or on joints, to obtain good results particular conditions are needed, some of which are more difficult to obtain in a dairy farm than in a teaching hospital. Most operations can be done with the cow standing in the chute, without sedation: this reduces personnel assistance necessity. It's advisable to apply a plastic sheet to separate the limb from the body of the cow in order to reduce operating field contamination. The skin of the affected digit should be accurately washed, clipped and disinfected, practices that sometimes require more time than surgical operation. Intravenous regional anesthesia (IVRA) provides an effective analgesia of the distal limb for over a hour; 15-20 ml of a 2% lidocaine solution, are injected in digital collateral veins or in lateral safena vein, after a tourniquet is applied above the dewclaws. It's possible to associate in the anesthetic, Penicillin G Na 10.000.000 I.U, Ampicillin Na 2 g or Cefazolin 250 mg<sup>6,12</sup>: a good antibiotic concentration is obtained in the digit, with low doses of drug. In too much weakened animals or with impressive anatomical lesions results could be poor: in the early days after conservative surgery the pain increases and the general conditions of the cow usually get worse; in this case the amputation is to be preferred providing a more quick pain disappearance. On the contrary, in cows living on slatted floors or in mountain pasture, digital amputation is unsuitable. The farmer should dispose suitable spaces and labour supply to correctly manage a long-term unhealthy cow and should be willing to support the valued expenses. The estimated cost of a DIP joint resection, in 1996, was about 180.00 £., not including the visit charges for 4 follow-up examinations<sup>7</sup>. Today these costs are higher and depend on surgical time, materials for surgery, post surgery cares and drug administration. For this reason, it's advisable to bring about these techniques only on high-valued animals

The long post operative cares after a joint resection are as much important as the proper surgical technique applied: the cow should be isolated in a clean and dry environment and, first of all, this condition should be maintained for no less than one month; general antibiotic therapy has to be prolonged for at least 15 days, depending on the outcome of the clinical case. Post operating contamination lead to frustrating situations with delayed healing or relapses. In modern dairy farms it's easier to breed sound animals or animals with a similar problem than animals with a particular problem: if these conditions are not satisfied it's better to perform radical surgical therapy. Post operating treatments require, depending on the surgical technique used and on the clinical evolution, from 4 to 6 checks that should be done personally by the vet or by skilled member of a team. Besides, it's necessary to perform surgery only in farms located within the normal area of work, not too far from home, to reduce the waste of time due to movements.

All this entails remarkable work engagement for the veterinarian, not easy to gain with the rest of daily practice

## **Clinical Cases**

### Case 1

Mediterranean water buffalo, 12 years old, female, submitted to clinical visit for a 10 days old severe lameness, degree 4.5, according to Manson & Leaver<sup>9</sup>, at left foreleg. She was reluctant to walk and milk production was decreased. Body temperature 39.8°C. At a preliminary inspection the bulb of the inner fore-claw was slightly swollen and painful at palpation; after functional trimming a white line separation was evident in claw region n. 3. Once removed the loose horn, a

soft grey coloured necrotic corium, without pus, appeared. This tissue was partially removed with a scalpel blade, the lesion bandaged with antibiotic powder and a block applied under the healthy claw. A systemic antibiotic therapy (L.A. oxytetracycline 30 mg/kg/ every two days for 3 times) was administered. One month later the animal was still lame; an abundant granulation tissue had completely substituted the necrotic tissue; a fistula was checked and the probe entered reaching the underlying third phalanx. Surgery was performed with the animal standing in a chute; the affected claw was washed and disinfected, a tourniquet was placed above the dew claws and intravenous regional anaesthesia (IVRA) was performed injecting 20 ml of a 2% lidocaine solution, in a digital collateral vein. The exuberant granulation tissue was removed; all necrotic tissues and the affected bone were curetted with a hand curette. An antiseptic elastic waterproof bandage concluded the surgical procedure; the buffalo was admitted in the herd and a seven days general antibiotic therapy (penicillin procaine plus neomycin) was instituted. The bandage was renewed only once, 6 days after surgery and left fall by itself. In the following examination, on the 22<sup>nd</sup> day, the buffalo had lost the block and was markedly lame. The lesion, covered by a regular granulation tissue, was cleaned and topically treated with oxytetracycline spray and a wooden block was applied again. On day 52<sup>nd</sup> since surgery, the solear lesion was healed, with a thin layer of solear horn tissue, and the lameness disappeared.

#### Case 2

Heifer Brown, Swiss, 26 months old; two months before calving she reported a deep puncture wound on the abaxial coronary region of hind right digit. Systemic antibiotic treatment was instituted by the farmer, but 3 weeks later the cow was still lame and for this reason was submitted to a clinical visit. The hind right limb, few centimetres above the coronary border, showed a hard painful swelling with a deep penetrating wound, discharging purulent material. The probe deeply entered through the sinus; radiographs showed a bone sequestrum in correspondence of the second phalanx and an intensive periosteal new bone production. The heifer, restrained in a standing chute, was submitted to a surgical procedure for the removal of the bone sequestrum without sedative administration. A plastic sheet was placed on the backside of the cow to protect the lesion from contamination during surgery. After routine surgical preparation, IVRA, associated with 2 g of Ampicillin Na, was administered in an accessible vein. A ten centimetres vertical incision of the skin was carried out along the fistula; the skin was detached from the periosteum and the tissue around the fistula removed. The surgical wound was enlarged with the help of a retractor and periosteal bone removed with an osteotome, to make easier open the cloaca. A yellow coloured bone sequestrum, immersed in debris and pus, was easily taken away and necrotic tissue curetted up to the healthy bone. Swabs were taken and sent to a lab: microbiological tests were negative for bacteria. A flushing with saline plus gentamycin was made, a drainage applied and the skin sutured. The lesion was protected with a bandage and a wooden block was applied under the healthy digit. Medical therapy consisted of cefquinome (1 mg/kg/sid / for 8 days) and diclofenac sodium (2,5 mg/ kg/ die for 3 days). After surgery lameness quickly improved, the drainage was taken out on day 3 and stitches on day 12. For some days the sinus still discharged pus: lavages with povidone iodine, 0,1 % were instituted and the affected limb bandaged. After 45 days the cow lost the block, without showing lameness signs.

#### Case 3

Cow, Holstein-Friesian, 28 months old, belonging to a 400 milking cow herd, presented a 2 weeks old severe lameness (degree 4.5), with difficulties in standing and walking. The farmer confined the cow in a box and started a general antibiotic therapy without any improvement. The left outer hind limb was notable swollen and painful at palpation; on the abaxial coronary border, an exuberant granulation tissue formation, with a fistulous tract was present; a probe entered deeply through the sinus, in the DIP joint. Radiographs showed an increasing of the interdigital space, navicular bone and pedal bone osteolysis. The diagnosis was septic arthritis of DIP joint, deriving from a white line infection. The animal was restrained in a cattle chute and after surgical preparation, IVRA was administered lidocaine 2%, 20 ml plus ampicillin Na 2 g. According to K. Nuss & M.P. Weaver the sole of the affected hoof was thinned. A vertical skin incision started under the dewclaw and continued distally to the bulb where an oval piece of solear horn, corium and digital cushion were removed. The distal segment of DDFT was already detached from its insertion on the 3<sup>rd</sup> phalanx and, after the placement of a retractor, was distally dissected to the annular ligament. The changed navicular bone was removed cutting the axial, the abaxial and the interosseum ligament. Dense pus was collected in the interdigital space and in the articular pouches. The resection started drilling, with a 6-mm. diameter bit, the tuberculum flexorium; then a hole was drilled from the plantar point to the dorsal surface of the claw to emerge just below the coronary band. The articular hole was enlarged, axially and abaxially, to remove the necrotic cartilage, bone and subchondral bone; a joint lavage was made with saline during drilling to avoid heat damage of tissues and to flush away debris. Once finished the curettage with a hand curette, gauze with tetracycline and sulphonamide powder was inserted within the cavity; the lesion was then protected with a waterproof elastic bandage to stop bleeding. A block was put under the sound claw and the two digits wired together, to avoid digital overextension. Post surgical cares consisted of: isolation, antibiotic (cephalexine, 8mg/die / for 14 days) and anti-inflammatory (diclofenac sodium 2,5 mg/kg /sid / for 3 days) systemic therapy, and periodical examination. On day 5<sup>th</sup> the gauze drain was removed and the bandage renewed; during the following checks (days 11, 17, 31, 50) it was noticed that granulation tissue filled the retroarticular cavity completely covering the phalanxes since day 17. From day 11, within the surgical wound, pus was present in spite of povidone iodine 0,1% flushing and antiseptic dressings. Since day 31 the wound has been left without bandage. From the 50<sup>th</sup> day the cow was introduced again in the herd even if the solear surface wasn't completely covered by new horn tissue. As after effects, the digit was slightly swollen and hyper extended.

#### Case 4

Cow, Holstein-Friesian, 6 years old, 2-parity number; she had been severely lame since 20 days before, with the extremity of the hind left limb swollen. The cow had hyperthermia, was reluctant to walk and milk production was rapidly decreased. The farmer isolated the cow in a tied stall and began an antibiotic systemic therapy. To a close inspection the outer digit was overextended and tumefied in the plantar side, from the bulb up to some centimetres above the corresponding dewclaw. The claw was trimmed and close to the bulbar skin horn junction, a corium lesion with a fistula was found, probably caused by a white line infection. The swelling was painful at palpation; no pus discharge came out of the sinus through which a probe was inserted and deeply driven all along the course of the flexor tendons sheath; the diagnosis was septic tenosynovitis of digital flexor tendons and, according to literature, a radical resection of SDFT, DDFT and their sheath (DFTS) was performed. The cow was restrained in a standing crush; the limb was prepared for surgery and, after a tourniquet was placed, 20 ml of lidocaine

2% were injected in the safena lateral vein. A skin incision was made on the flexor side of the affected digit, starting 5-8 cm above the dew claw, circumscribing the dew claw axially, towards the skin horn junction of the bulb; the incision was deepened and the sub skin tissues, the annular ligament and the DFTS, all along its length, were dissected paying attention not to damage, axially, plantar common digital artery, vein and nerve. Tendons and synovial structures were necrotic, indistinguishable and adherent to peritendineous tissues; the affected tissues were removed, as much as possible, partly with a scalpel blade and partly with a hand curette, paying attention not to cut proximally the DFTS on the other side. Then an antiseptic lavage with a povidone iodine 0,1 % solution was carried out and, finally, an antibiotic soaked gauze drain was placed and the skin partially sutured. A block was put under the sound claw, and the limb protected with an elastic and impermeable bandage. The two digits were fixed together with a metallic wire, which was without issue on the already present cocked up toe. The cow was subjected to general antibiotic (cefalexin sodium 8 mg/kg/sid / for 14 dd.) and anti-inflammatory (diclofenac Sodium 2,5 mg /kg /die for 3 dd.) therapy. At the first check, on day 6, the cow had reduced lameness degree and improved general conditions; the drainage was removed and a lavage performed to eliminate residual exudate; a new bandage was made. On twelfth day the stitches were taken away: the wound was healing with an exceeding granulation tissue in the proximal third. The lesion was subsequently checked on days 18 and 24. Thirty-eight days after surgery the prominent granulation tissue was incised and the internal necrotic tissue curetaged. After 50 days the cow was released in the herd.

#### Case 5

Cow Holstein-Friesian, 4 years, at the first examination the cow had degree 2 lameness, and a slight, unilateral bulb swelling of the hind right outer digit. The cow didn't have temperature. After trimming, an absconding white line disease was diagnosed with a sinus in the abaxial wall, through which a probe penetrated toward the inner side of the bulb for 1 centimetre. A block was applied and systemic antibiotic therapy for 7 days administered, while awaiting possible surgery. One week later the lameness was increased and the swelling worsened, involving the total bulb. Under manual pressure dense abundant pus came out of the sinus. The probe deeply entered and had contact with the bones. The diagnosis was retroarticular abscess. The cow was restrained and after surgical preparation and IVRA the sinus was enlarged to permit the passage of a finger; digital palpation of retroarticular space revealed remarkable irregularities of the navicular bone and of the distal end of DDFT. The abaxial / axial approach was changed to a plantar one, according to Nuss & M.P. Weaver. The distal end of DDFT, partially avulsed, and the deeply modified navicular bone were removed; surrounding necrotic soft tissues and pus were curetaged. After an antiseptic lavage, the wound was bandaged with antibiotic powder, a block applied and the two digits wired together. Systemic wide-spectrum antibiotic therapy was administered for ten days. The lesion was checked, disinfected and bandaged on days 6, 14, 24, 40; from day 24, being the joint completely covered and protected from granulation tissue proliferation, the bovine was introduced again in the stall. In all checks, superficial pus covered the lesion, slowing down the usual recovery time.

#### Case 6

Cow, Holstein Friesian, 4 years old, 2 parity number, was subjected to a trauma that caused the partial avulsion of dorsal wall and coronary margin of the left hind claw. In few days the digit became swollen: the cow was severely lame and general health condition worsened, with a quick

decrease in milk production. About a fortnight later, during a routine hoof trimming session, the cow was submitted to a clinical visit: body temperature 39.8°C, loss of body weight, severe lameness (degree 4) and digital swelling were the major symptoms. The bulb and the coronary region were notable tumefied; in correspondence of the traumatised coronary border and wall laminae granulation tissue, tending to prolapse, was well developed. From a sinus exudate came out; a probe, inserted to value deep structures involvement, entered the DIP joint. No radiographic exam was performed. The diagnosis was septic arthritis of DIP joint of traumatic origin. Digital disarticulation through the proximal interphalangeal joint was carried out<sup>2</sup>. The affected limb was prepared for surgery: the two claws were accurately cleaned, the skin clipped and disinfected and IVRA was performed. A deep skin incision was made along the axial coronary margin and continued above the abaxial skin lesion, in order to remove all infected tissues. The affected hoof was transected with an obstetrical wire; a vertical skin incision was made, abaxially, from the lower margin to the proximal interphalangeal joint. Sub-skin tissues, interphalangeal ligaments and the joint capsule between the 2<sup>nd</sup> and the 1<sup>st</sup> phalanx were resected with a scalpel and the middle phalanx taken away. The articular cartilage was removed with a hand curette, to stimulate the development of the granulation tissue. A triangular wedge of skin, adjacent to the vertical incision made abaxially, was cut to facilitate the suture of a cutaneous flap. A compressive elastic water resistant bandage, with antibiotic powder, was performed to stop bleeding and to protect the stump. A systemic antibiotic therapy was instituted (oxytetracycline 10 mg/kg/sid for 7 days). A block was applied under the healthy claw, to improve protection of the surgical wound, and the cow was confined in a box. Few days after surgery, the weight bearing was improved. The first check was on day 6: a blood coagulum and repairing granulation tissue covered the first phalanx; between the coagulum and phalanx dense pus was present. The coagulum was removed and the wound disinfected; the antiseptic bandage was renewed and systemic antibiotic therapy prolonged for an extra three days. On day 15<sup>th</sup> the stitches were taken out: the wound was almost completely filled by the new tissue and superficial pus was still present. A final bandage was applied and the cow introduced in the herd again.

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## THE BIOMECHANICS OF WEIGHT BEARING AND ITS SIGNIFICANCE WITH LAMENESS

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Dairy cows are exposed on a daily basis to housing conditions that influence the physiological function of the claws. Stress and improper feeding management practices predispose to metabolic changes and coriosis. The high concentration of animals makes cows walk on their own faeces and predisposes them to the chemical action of manure slurry and putrefactive bacterial growth. Walking and confinement on hard concrete surfaces causes an abnormal concentration of weight on certain points of the claw's weight bearing surface. Finally, certain animals have a genetic predisposition to abnormalities of claw conformation. The interrelationship of these factors lead to irritation and changes in the normal shape of claws, which leads to mechanical disorders in physiology of stance and locomotion. Weight-bearing of the claws is different depending upon the type of floor. On soft surfaces the more prominent parts of the wall and heels sink into the ground and thus the weight-bearing surface on the axial part of the sole increases. Weight is distributed homogeneously across the larger surface of the sole so that the excessive distribution of weight on specific critical claw zones is reduced. On hard surfaces changes in gait and weight bearing lead to an abnormal distribution of weight that disrupts normal function of the claw leading to discomfort, lesions and lameness. Faced with those conditions cows react to the pain by modifying their gait, which can also affect the upper skeleton. The interaction between flat and hard concrete and the normal weight-bearing surface of the claws can by itself be a major cause of stress and discomfort.

Why do most cows develop lameness of the lateral hind claw?

### **Overgrowth of Lateral Hind Claw**

Physiologically, the medial claw of the rear foot is relatively unstable because of a pronounced concavity of the sole from the abaxial to the axial wall and because of the shorter length of the axial weight bearing area. On a soft flooring surface the claw adapts to this peculiarity and the cow's clawprint is deeper abaxially and protrudes axially. One surface adapts to the other and weight bearing is balanced over the surface of both claws. But on a hard flooring surface this instability of the weight-bearing surface of the medial claw displaces more weight to the lateral hind claw, which becomes overloaded. The corium has limited room for expansion because it is housed within the horn capsule. So, when the claw bears weight inner bony structure compresses corium against the claw capsule causing blood to be pushed upward. This generates an extra blood pumping action. We call it the peripheral blood pumping system. If we compare the peripheral blood pumping system between the medial and lateral claw we realise that because the lateral claw gets more pressure it mobilises more blood. The increase in blood flow to the corium of the lateral claw leads to a higher rate of horn production. Also, while a cow is standing there is a slight lateral movement of weight through the hips that alternately displaces weight from one leg to the other. These changes of weight are concentrated on the lateral claw while the medial claw is influenced very little by it. These periodic changes in weight distribution result in greater

pressure of P3 (3<sup>rd</sup> Phalanx) on the corium that causes irritation of this sensitive tissue. This irritation causes hypertrophy and hyperplasia of the affected area and asymmetry of the claws becomes more apparent.

Extra forces exerted over the posterior surface of the lateral hind claw affect the inner sensitive structures that are in the typical area of the sole: projection of the flexor tuberosity of P3 and the white line. The chance of suffering contusion at the typical sole area and separation of white line increases.

The extra work of the lateral claw is also supported by comparison of P3 bones of both the medial and lateral claws. The lateral P3 much rougher. These biomechanical factors are described in the book “Cattle Foot Care and Claw Trimming” by E Toussaint Raven.

Some workers suggest that the asymmetry is not due to an overgrowth of lateral claw but to an excess wearing of the medial claw due to abnormal locomotion predisposed by enlargement of the udder. This theory can not be taken as a general rule but perhaps only applied to certain cases.

Claws of front legs are similar to each other in terms of size and stability. Further, front legs are connected to the upper body by tendons and ligaments that cushion the effects of variable weight distribution between the claws. Mechanical forces associated with variable weight distribution are less pronounced and difference in overgrowth between claws less consistent.

### **Overgrowth of Abaxial Wall and Toe Area**

As viewed from the lateral side, the normal claw maintains appropriate proportions between the length of its anterior margin and the height of the heel. In normal healthy claws the length of the heel is half of the length of the anterior margin. For a mature Holstein cow the length of anterior margin is 7.5 cm. Thus, the ideal length of the heel is 3.75 cm. This rate may vary from one cow to another depending upon the size and possibly breed of the cow. The length of anterior margin (front wall) and the heel determines the foot angle. In a normally proportioned claw the force is transmitted by the bony structure to the weight bearing surface and balanced proportionally along the claw.

The horn of the wall is the hardest horn in the claw and has a higher rate of growth than the horn of the sole. The toe tends to overgrow, mainly in confined animals. This causes the weight-bearing axis to be displaced further back resulting in weight concentration towards the heel. This causes excessive pressure over the area of the flexor tuberosity and increases the risk of bruises and ulcers at the area of the sole typical for the occurrence of sole ulcers.

Overgrowth of the abaxial wall leads to instability. When the cow bears weight on the foot the axial part of the sole tilts downward and the interdigital space separates. The position of P3 inclines and the flexor tuberosity becomes prominent. Force is displaced axially and the chances of sole ulcer increase. Claw trimming techniques that result in the removal of too much horn from the axial part of the sole can lead to the same undesirable result.

### **Overwearing of Toe Area**

The described phenomena of overgrowth appear mainly in intensive or semi-intensive operations where locomotion of the cows is not the major point. But there are two important situations where the major issue is the increased locomotion of animals.

- Intensively confined large herds milking three times daily with sand bedding in cubicles (free-stalls), large herds (1000 or more cows) where cows have to walk long distances daily on abrasive surfaces (concrete + sand), and herds on high concentrate diets for high milk yield inherent to such management practices that make these animals prone to rumen acidosis and laminitic insults that decrease horn quality and increase susceptibility to excessive horn wear.
- Extensive big herds (300 or more) with long distances to walk to and from pasture mainly in wet season. In this case probably there is an interaction between mechanical sole abrasion, softening of the horn due to water absorption and tilting of the apex of P3 secondary to metabolic alterations related to fiber content of pasture or in some cases feeding of some concentrate in the parlour.

Where increased locomotion is the major issue, the toe area of the weight-bearing surface becomes the most critical point. Horn production is slower than the rate of wear. The sole becomes too thin to fulfill its task of protecting the corium. Excessive wear of entire weight bearing surface of the claw develops. This may be complicated by interdigital dermatitis, which causes overgrowth of the heel (particularly in lateral claws of hind feet). This overgrowth of the outside claw heel of the rear legs moves the weight-bearing axis forward further contributing to the short toe and thin sole problem of lateral hind claw. In addition, there is no digital cushion in the toe area. Thus, the corium between the apex of P3 and the sole gets injured very easily. The first areas to become bruised and or abscessed are the apex of P3 on the sole (zone 5) and white line at toe lateral area (zone 2).

### **Influence of Disease in Claw Shape Changes**

Where some other cause of irritation is present this process of asymmetry is much more accelerated. Cows suffering chronic diseases as laminitis or dermatitis tend to have much bigger differences of height and volume between medial and lateral claw.

### **Biomechanical Changes Related to Different Diseases**

In digital dermatitis biomechanical changes are not consistent and vary depending upon the location of lesions. If a lesion is located in the typical area around the flexor interdigital cleft or over the heel bulbs, the cow will try to avoid pain by walking on her toes. This causes extra pressure and wear in the toe. If lesions become chronic overgrowth of heel horn tissue at one or both claws may be severe. If the lesion is located at the interdigital space or on the dorsal interdigital cleft the cow tends to avoid walking on her toes. She slides on the heel and advances her leg in an extreme manner with the consequence of overgrowth of the toe and abaxial wall and extra wear of the heel. Interdigital hyperplasia will show the same biomechanical changes. Some animals may develop a septic vertical fissure, if disease becomes chronic in which case the cow may walk on her heel bulbs with a total relaxation of flexor tendon function.

Chronic interdigital dermatitis leads to heel horn erosion and an extra irritation of the lateral heel bulb and thus a much bigger difference of height between the medial and lateral claw heel. Consequently the cow adopts a “cow-hocked” stance. Heel horn erosion, alone is a major cause of sole ulcer. Three forces concentrate at the same point: overgrowth of the lateral heel, P3 flexor tuberosity and erosion ridges. Heel horn erosion is a major cause of alterations of biomechanical balance in most herds and if hygienic management is improved important improvement of the back leg posture (and scoring) is observed.

Acute laminitis cases usually affect all eight claws with special concentration of pain on the toes because a possible tilting forward of p3. Cows advance their hind legs in order to avoid bearing weight on the toes adopting a “camping under” position and in extreme cases walk on the knees of their front legs. This is observed in feedlots and dairy herds (usually first calf heifers) with a high prevalence of laminitis. Chronic forms of the acute laminitic cases show animals with septic pododermatitis lesion at toe area with extreme overgrowing of the toe horn and weight displaced on the heels.

The chronic laminitic changes more common in European herds seem to be a consequence of the sinking of P3 after subacute laminitic insults. The sole becomes deformed and weight is changed from the heels at the stance position to a difficult transition to the tilted up extreme of the toe. This comes together with an important overgrowth of lateral claw and consequently a poor position score of the hooks.

Complicated sole ulcers and white line disease that develop deep digital sepsis are accompanied by necrosis of flexor tendon insertion on P3. There is a tilting of the whole claw, weight is transferred to the heel bulb with the rest of the claw bearing little or no weight.

## **Conclusions**

Cows can be lying down, standing or walking and each situation has a relationship to the development of lameness. While a cow is lying down, there is no force acting at the extremity so there are no chances of getting lame. So, improved cow comfort leads to more hours lying down should lead to better control of lameness.

Cows standing on hard floors concentrate weight on the overgrown areas of the claw and thus, have a greater chance for developing lameness associated with mechanical forces on the weight-bearing surface. From a mechanical point the chances of getting lame are related to the deformations of the claw and the hardness of the floor. Softening floors by use of rubber mats at feeding area and routine functional trimming are the best ways to minimise irregular weight distribution on the weight-bearing surface of claws.

Cows walking are subject to greater wear and reduced sole thickness. This wearing depends on the distance walked, the abrasiveness of the floor and the hardness of the horn. If the balance between growth and wear is uneven, soles get too thin and can not provide proper protection to the corium. Reducing the walking distance, getting smoother paths, and hardening the hoof horn by minimising moisture or by improving horn quality may be potential ways to decrease lameness from mechanical factors. Performance of functional trimming does not appear as a clearly efficient way to minimise lameness. It may be that careful trimming whereby just the

overgrowth of lateral heel is removed and the axial grooves are carved, can be helpful. But there are not clear studies that prove this and common sense says that there can be little help from horn removal where there is not enough horn to be removed.

Alterations in biomechanics can lead to an increase of lameness problems but improper feeding management and or chemical and bacterial insults play an important role in alterations of horn growth. Biomechanical changes are multifactorial.

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## CLAW TRIMMING – HOW SHOULD IT BE DONE? A COMPARISON OF TWO APPROACHES

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### Introduction

This paper is by no means intended to be a definitive description of the correct procedure for cattle claw trimming, but rather a discussion document which attempts to provide a summary of the main weight-bearing surfaces of the foot, then uses this information to understand the principles of hoof trimming. Differences in systems of hoof-trimming are described, and unresolved issues are listed for further discussion. Much of the information presented is a comparison between the texts of Cattle Footcare and Claw Trimming (Toussaint Raven 1985) and Cattle Lameness and Hoofcare (Blowey 1993).

### Normal Weight-bearing

There is general agreement that the correct weight-bearing surfaces of the foot run from the heel, around the abaxial wall to the toe, and caudally from the toe along the axial wall until the point when axial groove runs dorsally. The white line and sole adjacent to the wall may also be weight-bearing, but the central sole area of zone 4 is generally concave. It is therefore not weight-bearing when on hard surfaces such as concrete, but will become partially weight-bearing when the claw sinks into softer surfaces of natural grazing. Toussaint Raven reports that in hind feet the axial wall of the medial claw is less pronounced than that of the lateral claw and, as a consequence, greater weight is taken on the lateral claw.

### Hoof Overgrowth

Overgrowth of the hoof will occur when the rate of growth exceeds the rate of wear. The growth may be in a normal direction, or the overgrowth may be abnormal leading to distortion of the hoof. The common forms of overgrowth are as follows:

#### Elongation of the Dorsal Wall

The wall at the toe is the hardest of any part of the foot, having a high tubule density (80 per mm<sup>2</sup>) and the greatest maturity (75mm from coronary band to toe, divided by 5mm/month growth = 15 months). Under normal conditions, the rate of hoof wear is therefore likely to be less at the toe than at the heel, and as a consequence *hoof overgrowth occurs primarily at the toe*. This leads to the toe being lifted and a change in the angle of the dorsal wall from 35° to 25°, depending on the extent of the overgrowth. The overgrowth is exacerbated because the horn tubules and the direction of growth are parallel with the dorsal wall at the toe, whereas at the heel the tubules and hence the direction of horn growth curves under the sole. These changes may be partially reversed in the post-partum animal when increased hoof wear from excess standing coincides with reduced horn growth in the periparturient animal, and a period of negative net growth occurs at the toe.

### **Overgrowth of the Sole**

A ledge of sole horn may form in zone 4 and grow towards the axial space. This is most common in the major weight-bearing claws (lateral hind and medial fore) and in animals kept on concrete surfaces. In more advanced cases the axial sole wedge can become the main weight-bearing surface of the foot and in zone 4 will predispose to sole ulceration. This axial sole overgrowth is thought to arise from a combination of uneven wear (standing on concrete) and the uneven suspension of the pedal bone. As the bone is firmly suspended to the abaxial laminar corium by the digital ligament, but only poorly to the axial corium, slight rotation may occur during locomotion and this leads to regular trauma on the sole corium at zone 4, which in turn can stimulate overgrowth.

### **Overgrowth of the Wall**

Overgrowth of the wall may take several forms. The most common is where the abaxial wall rolls under the sole and as a consequence the abaxial surface of the wall may become weight-bearing. This may or may not be associated with corkscrew toe. The wall may also overgrow in the opposite direction, viz. to splay away from the sole. This may occur at either the abaxial or axial wall and can lead to widening and weakening of the white line. Dorsal rotation of the toe, leading to a concave dorsal wall, has been suggested to result from inflammation of the laminar corium, although Ossent and Lischer (2000) were unable to demonstrate that inflammation of this laminar corium was ever a significant feature.

### **Disparity of the Claws**

A common form of overgrowth is the development of a disparity in claw size, the most common being an overgrowth of the lateral claw in hind feet and an overgrowth of the medial claw in front feet.

## **CLAW TRIMMING**

All authors agree that the purpose of hoof trimming is to restore weight to the correct weight-bearing surface of the foot. Stages of hoof trimming can be described as follows:

### **Length of Toe**

The toe should be trimmed to the correct length. Toussaint Raven describes this as 70mm, whereas the current author considers 75-80mm as a safer distance. This could be partly because of a difference in techniques at a later stage. Toussaint Raven recommends first trimming the medial claw to the correct length. While this may be acceptable for functional trimming, this authors favoured approach is to check the sole surface of both claws for lesions before removing any significant length of toe from either claw and this is particularly the case with lame animals. For example if lesions exist in the lateral claw, then both the rate of healing and the welfare of the cow are improved if the majority of the weight is transferred onto the medial claw. Equalisation of weight-bearing can be achieved at a later date. One suggested reason for this difference is that UK cows may spend longer walking on flint surfaces than their Dutch counterparts, and hence a thicker sole is required (Dawson 2001).

A further reason to not remove excess length from the toe is that a good deal of hoof trimming is carried out at drying off. From stage two of hoof trimming it can be seen that if the toe is cut

shorter than the sole will automatically be trimmed thinner. As all cows undergo a period of 'negative net growth' in the immediate post-partum period – hoof growth slows but hoof wear increases - it is important that an adequate thickness of sole is present to avoid excess thinning. Excessively thin soles can lead to bruising of the corium and subsequent formation of sole hoof defects.

If trimming is being carried out using clippers and a knife, the clippers can first be used to remove horn growth at the toe, then continue by removing part of the wall back towards the heel. Great care needs to be taken to avoid removing excess wall, otherwise the sole will become the weight-bearing surface.

### **Removal of Sole**

Stage 2 is the removal of excess sole horn. This will be most important at the toe. Provided that the dorsal wall has not been cut too short it should be possible to remove sufficient sole at the toe so that the white line reappears, running from the heel around the abaxial wall, to the toe and then caudally along the axial wall. When the white line is visible 2-5mm from the outside edge of the wall we can be fairly confident that the wall is once again the major weight-bearing surface of the foot. This is an area of dispute between the proponents of differing methods of hoof trimming. During a discussion at the Parma Symposium, Italy (Burgi 2000, personal communication) it was considered that the cow should be left with a 4-5mm "step" at the toe, as this will improve locomotion. Burgi considers that this allows the cow to "break over" when walking, i.e. locomotion is improved because as she moves forward there is no point at the toe to contact the ground. It is this author's opinion that cows do not "break over" when walking, although they may occasionally do so on the rare occasions that they run. This is because as the foot is lifted and moved forwards, the angle of the sole rarely reaches much more than a 45° angle to the ground surface. For "break over" to be a problem, the sole would need to reach nearly a 90° angle with the ground.

The difference between the two techniques will arise at least partly from the anticipated "correct" length of the dorsal wall. If 70mm is chosen, then in a significant number of cows it will not be possible to remove sole to expose the white line at the toe without exposing the corium. If 75-80mm is chosen, then weight-bearing on the dorsal wall can be achieved. As new-born calves or grazing cattle are rarely seen with a "square-ended" toe, then the longer toe length seems the most logical. The differences in weight bearing and sole thickness between a 75mm anterior wall with white line at the toe and a 70mm wall with a square ended toe may be very little, but surely we should try to decide which method is most beneficial for the cow. Hopefully this will be an area for discussion.

### **Removal of the Axial Ledge**

The central sole area beneath the flexor tuberosity of the pedal bone should be non-weight-bearing. Any overgrowth of the axial sole wedge should therefore be removed and the axial wall "dished" to allow greater space in the interdigital cleft. This is thought to reduce impaction by debris and so reduce the probability of conditions such as interdigital skin hyperplasia and interdigital necrobacillosis. Toussaint Raven (and the current author) was unaware of any evidence to support the benefits of "dishing" the axial sole surface. However, this must surely be a subject for further research.

### **Equalisation of Weight-bearing**

Stage 4 consists of equalising weight-bearing on the medial and lateral claws. This normally means removing additional horn from the lateral hind claw and medial fore claw. The lateral hind claw is thought to overgrow as a result of a combination of :

- greater variation in weight-bearing on the outer claw
- poorer suspension of the pedal bone
- the forward propulsion achieved by the hind feet leads to the lateral claw impacting its weight-bearing surface in an oblique direction (Bugi 1998)

At this stage it may be necessary to remove horn from the heel of the larger claw. In many instances, especially on intensive slurry/concrete housing systems, the heel has already been eroded and little or no horn should be removed. This author does not believe it necessary to remove the small pits and fissures associated with heel-horn erosion. To do so could remove valuable weight bearing surface at the heel and lead to caudal rotation of the claw, which is undesirable. Only gross under-running of the heel horn is likely to be detrimental to the cow and needs investigation. Minor defects are best controlled by footbaths. However, heel will need to be removed from the larger claw to restore even weight-bearing.

### **COMMON FAULTS IN HOOF TRIMMING**

Common faults seen by the author include the following:

1. Excessive shortening of the toe. If sole is then removed (stage two), the sole will become too thin, the corium becomes compressed and subsequent bruising can lead to severe lameness. If the toe is inadvertently cut too short, stage two should not be attempted. Even if this exposes corium at the toe, major lameness will not develop unless sole is removed. At the toe the corium is surrounded by horn and hence it will not become compressed. This could lead to excess weight-bearing on the white line and caudal rotation of the foot however (see point two below).
2. Leaving a square-ended toe. Weight is then taken on the sole and white line and not on the wall. This only applies to the point of the toe however, and its importance will depend on the length of white line exposed at the toe.
3. Removal of the axial wall. Some farmers will remove the axial wall on the misconception that the hooves should not touch at the toe. The axial wall is an important weight-bearing surface. Its removal will destabilise the claw, and could predispose to rotation.

### **Problem Areas**

The following are hoof deformities that produce difficulties with trimming. The list is by no means exhaustive, and it is intended to stimulate discussion rather than set out to be a comprehensive review. In most instances the advice can only be 'proceed with caution', and comments from delegates will be welcome! The most important factors must be to prevent the deformities from occurring, and to trim before they become too advanced. If deformities are

allowed to become excessively advanced, producing gross distortion of the foot, before they are corrected, this can produce secondary stretching of support ligaments and tendons.

### **Lateral Splaying of the Abaxial Wall**

In a proportion of cows the abaxial wall splays laterally to produce a marked widening and weakening of the white line. The defect may be so pronounced that the abaxial wall is almost parallel with the bearing surface. If there is ample thickness of sole then it may be possible to remove sufficient wall and sole to a level above the defect and return weight bearing to the wall. In many cows however, this is not possible, and the options are to either remove all of the deformed wall in the hope that subsequent growth will be in the correct direction, or to remove the wall only down to a point where it becomes weight bearing. In the first instance the sole and white line will be the weight bearing areas, and this is clearly undesirable. In the second, the wall defect will not be fully corrected.

### **Hooves with Partial Rupture of the Deep Flexor Tendon**

Rupture of the deep flexor tendon, for example as a complication of a sole ulcer, leads to a dorsal rotation of the toe, and elongation occurs because there is insufficient wear at the toe. If standard hoof trimming techniques are used, penetration of the corium of the sole at the toe may occur. This defect needs to be identified at the outset, and allowances made to avoid removal of excess sole.

### **Corkscrew Claw**

The degree of correction achieved by standard techniques will depend on the severity of the abnormality. In some cows it may be possible to remove sufficient wall to correct the distortion, although it is difficult to gauge the correct level for the sole and continual checking by 'thumb pressure' is needed to avoid excess thinning.

### **'Turkish Slipper'**

Whilst it is accepted that there may be no evidence for sinking of the pedal bone within the hoof, care is needed when trimming hooves with pronounced dorsal deviation of the toe. This is because in a proportion of cases the sole at the toe does seem to be surprisingly thin, and with these cows there is a risk of penetrating the corium. Once again, caution should be exercised when trimming.

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## CLAW TRIMMING: AN ADAPTATION OF THE DUTCH METHOD

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The purpose of the claw capsule is to support the cow's weight and to protect the underlying corium and associated structures. In housing or management conditions that predispose to excess wear or in circumstances whereby horn of the sole becomes too thin as a result of over-trimming, bruising and trauma of the corium may occur due to the sole's inability to properly support weight-bearing. This is particularly important when cows are housed on hard flooring surfaces (such as concrete). On the other hand, housing conditions that reduce the normal rate of claw horn wear may lead to claw overgrowth and thus overburdening that increases potential for development of claw disease. Therefore, foot care programs that incorporate a biannual evaluation of claw conformation to determine the need for trimming are recommended.

The purpose of claw trimming is to re-establish normal function by correcting claw horn overgrowth thereby restoring appropriate weight-bearing within and between the claws of each foot. A claw trimming method based on that of Toussaint Raven is preferred by these authors because it incorporates important guidelines that prevent over-trimming and other trimming-related errors that often may cause lameness. The method describe here is a slight modification of the Raven method and incorporates a fourth step in the trimming procedure which is designed to ensure balance between the heels of the medial and lateral claws. It is the opinion of these authors that heel balance is particularly important in consideration of the incidence of claw lesions (heel ulcers, sole ulcers and white line disease at the junction of the heel, sole and abaxial wall) in the region of the heel.

### Trimming Method

**Step 1:** The primary objective of this step is to restore appropriate weight-bearing within the claw. A dorsal wall length of 3 inches which correlates to a sole thickness of 5-7mm, is regarded as ideal for the average sized Holstein cow in order to facilitate appropriate distribution of weight-bearing pressure (forces) within the claw and provide sufficient sole protection to the corium.<sup>6</sup> Overgrowth of the toe will result in displacement of the weight-bearing axis towards the heel.<sup>6</sup> This will increase the weight-bearing pressure in the heel which, even with normal weight-bearing dynamics, receives most of the pressure within the claw.<sup>6,7</sup>

Because the medial claw of the rear foot is more representative of the normal claw (usually less overgrown), this claw is used as a model for the more overgrown lateral claw.

Step1 is started by reducing the dorsal wall length of the medial claw to 7.5cm.

This is best accomplished by using a gauge of the same length and a pair of nippers. Accurate determination of the dorsal wall length is only possible if the claw capsule has a normal shape. Curvature (notching or buckling) of the dorsal wall as commonly seen with laminitis and screw claw complicates this procedure. It is therefore proposed that in such cases the front wall is straightened by using a rasp or an angle grinder fitted with a course sanding-type disk. The authors have never observed any complications following this procedure.

Next, the weight-bearing surface of the medial claw (wall and sole but not the heel) is trimmed in order to remove overgrowth until a sole thickness of approximately 7mm (not less than 5) is retained at the toe. This estimation of sole thickness is achieved by retaining a 0.25-inch depth at the toe, i.e. the cut end of the dorsal wall is elevated by 0.25 inches off the bearing surface.

Trimming of the wall and sole should result in a flat bearing surface, so that it will be at right angles to the long axis of the metacarpus (tarsus) in the standing position. This ensures that the cow has a flat and stable weight-bearing surface on a hard, flat walking surface.

The heel of the medial claw is not trimmed unless overgrown, since the heel of the lateral claw shows overgrowth in the majority of cases. However, the ratio between heel length and available bearing surface (heel, sole, wall) should always be assessed. A relative small bearing surface and long heel will result in very unstable weight bearing with the back of the heel acting as a pivot point. In such cases the heel length should be trimmed shorter which will result in a longer and more stable weight-bearing surface. The authors use 1.5 inches as a general guide to determine the correct heel length.

**Step 2:** Using the previously trimmed claw as a guide, trim the toe of the lateral claw to the same length as the medial claw. Next, trim the weight-bearing surface of the lateral claw to the same level as that of the medial claw. In this instance, unlike the medial claw, trimming may be started on the heel since, as stated before, the lateral heel of the outside hind claw is almost invariably overgrown relative to the medial claw. If trimming is carried out with a knife, long strokes should be used in order to create a flat bearing surface from heel to toe and also across the width of the sole.

When this step is complete, holding the front walls at the same level, the weight-bearing surfaces across both toes should be flat and balanced.

**Step 3:** The sole has a natural slope at the interdigital space, which tends to become overgrown particularly in the lateral claw of the hind leg.<sup>2</sup> The sole should be shaped and sloped so that the inner most back portion of the sole slopes toward the center of the claws. The slope includes that part of the sole, which extends from the end of the axial weight-bearing surface of the wall and white line, to the heel. Excessive cupping or sloping is not necessary since removal of sole overgrowth at the "typical place" for sole ulcer development is one of the primary objectives of this trimming procedure. Sloping also serves to open the interdigital space thus aiding in the prevention of manure entrapment. Excessive sloping of the sole may lead to instability of the weight-bearing surface, with excessive splaying of the claws, and excessively thin soles at the axial weight-bearing surface at the toe has been observed (SR van Amstel – unpublished observation).

**Step 4:** The biomechanics of weight-bearing usually in combination with claw disease, such as interdigital dermatitis and laminitis, will result in heel horn overgrowth.<sup>2,6</sup> This applies particularly to the outside heel of the back leg. Excessive weight-bearing can predispose to lameness producing claw lesions such as white line disease and sole ulcer.<sup>2, 6</sup>

Results using a pressure measuring device have shown that within the foot, the highest pressure is in the heel.<sup>7</sup> The reestablishment of heel balance between claws therefore becomes an important consideration in the application of claw trimming procedures. The weight-bearing surface should be flat across the heels of both claws. To achieve this, trimming of the inside heel (back leg) should be avoided in most cases, unless overgrown. Achieving heel balance requires a good view of the heels preferably from above and behind. A line which runs down the back of the metacarpus/tarsus should make a 90 degree intersect with a line running across the bearing surface of both heels. Such a view is easiest to achieve successfully in a stand up chute. This assessment of heel balance is very difficult to achieve with the use of a tilt table. Heel balance is therefore more dependent upon view and position of the trimmer rather than the application of any particular trimming method unless such a method should involve lowering the heel height of the medial claw of the hind leg. In such cases heel balance will be very difficult to achieve.

### **Sole Thickness: Comparison of 2 Trimming Methods**

Sole thickness has become an important consideration in the application of trimming methods since thin soles have become an important predisposing factor to lameness in the US.<sup>4</sup>

Accurate assessment of sole thickness is difficult. Determination of sole thickness in live cattle has been described using ultrasonographic imaging<sup>5</sup> Application of this technique on a herd basis may be difficult.

Sole thickness was determined after trimming claws with overgrowth (toe length more than 3 inches) using two different approaches. In both approaches a dorsal wall length of 3 inches was used as a standard. Trimming was carried out as follows:

#### **Method 1.**

Following reduction of the dorsal wall length to 3 inches, sole thickness was reduced until reconnection of the white line occurred (i.e. the white line at the toe becomes visible). This was used as the guideline to estimate sole thickness (called the **white line method**).

#### **Step 1**

- Reduce toe length to 3 inches on both claws using a gauge as a guide.

#### **Step 2**

- Reduce the sole depth to the point where reconnection between the abaxial and axial white line was first observed (i.e. the white line at the toe becomes visible). The same approach was used for both claws. The sole surface was kept flat during trimming.

#### **Method 2**

Was carried out according to the 4-step adaptation of the Raven method as described above.

All trimmed claws (both methods) were cut in cross section and measured 1.25 inches from the toe. Sole thickness was compared between the 2 trimmed groups.

There was no significant difference between the 2 groups. Using the white line method, 7 of 48 claws (14.6%) had a sole thickness of less than 5 mm where as only 1 of 66 claws (1.5%) in the

Dutch method group recorded a sole thickness of less than 5 mm. (S.R. van Amstel – unpublished data). From this, it seems that the Dutch method of trimming provides a more consistent and accurate estimate of sole thickness. This method would therefore, in general provide better protection for cattle on concrete surfaces.

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## A REVIEW OF CURRENT PAIN MANAGEMENT IN RUMINANTS – THE LAME COW MODEL

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### Introduction

A survey of British cattle practitioners published in 1997 (Jones, 1997) identified lameness as being their highest priority for research, together with the need for further development of analgesics to be used in cattle. This coincided with the publication of a lameness incidence of 54.6 new cases per 100 cows per year (Clakson *et al.*, 1996) reported by from of study of 37 dairy farms in the UK which was carried out between 1989/91. Clarkson and co-workers also reported an annual lameness prevalence of 20.6%. Whay *et al.* (2002) subsequently reported a very similar lameness prevalence of 22.1% from a study of 53 UK herds visited during the winter of 2000/01. The continued magnitude of the lameness incidence and the concerns of cattle practitioners serve to highlight the problems faced by all those associated with dairy cattle health and welfare.

It is, however, not simply the persistently high levels of lameness that is so worrying but the implications of lameness for the individual animal regardless of how many are affected. This is a combination of a compromise of the animal's ability to function within the herd or flock, the pain and suffering associated with lameness and a reduction in productivity.

In order to understand how the pain associated with lameness is likely to affect the animal as well as how to approach the management of this pain it is necessary to review the physiological mechanisms of pain. It must be remembered that pain always has an emotional component which influences how the individual interprets and responds to the physiological signals sent from the site of damage. This will be influenced by previous experience of pain, how pain reduces an individual's ability to cope with daily tasks and in the case of cattle and sheep will be entwined with their natural desire to conceal signs of injury from potential predators.

### Mechanisms of Chronic Pain

In 1965 Melzack and Wall identified a set of inconsistencies surrounding the behaviour of pain. These are listed in the box below.

1. The relationship between injury and pain is highly variable.
2. Innocuous stimuli may produce pain.
3. The location of pain may be different from the location of damage.
4. Pain may persist in the absence of injury or after healing.
5. The nature and location of pain changes with time.
6. Pain is not a single sensation but has many dimensions.
7. There is no adequate treatment for certain types of pain.

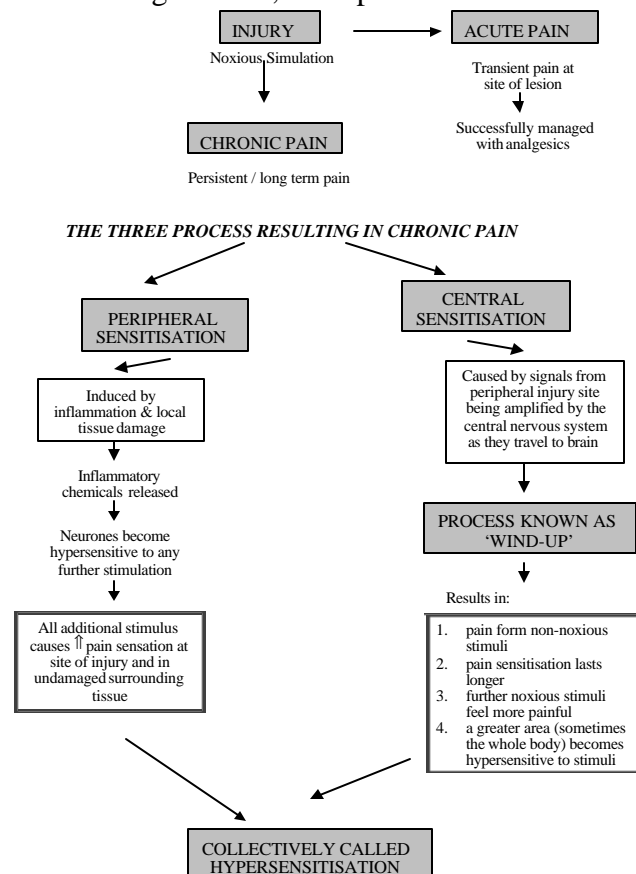
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It is these inconsistencies which make suffering so great and the successful management of pain a considerable challenge.

Although there are three physiological processes resulting in chronic pain two have a particular relevance to lame animals these are shown in Figure 1.

**Peripheral sensitisation** is caused by local responses to injury or trauma, usually involving inflammation, and involves firstly the area of primary sensitisation that is at the site of the lesion or injury itself. This then becomes surrounded by a ring of secondary sensitisation which affects tissue that is otherwise apparently undamaged. The result of this sensitisation is hyperalgesia. This is an increased sensitivity to a noxious stimulus or put simply any subsequent painful stimulation in the sensitised area feels more painful than it would have done previously. In addition a further phenomenon termed allodynia occurs. Allodynia describes the effect when a non-noxious stimulus, such as a light touch, feels painful.



**Figure 1.** The pathophysiological processes resulting in chronic pain

Central sensitisation is an increased gain or amplification of the neural signals of pain as they travel along the spinal cord to the brain. Woolf presented the evidence for this phenomenon in 1983. Woolf recognised the consequences of noxious stimulation resulting from the winding up of the central nervous system as well as from damage at the peripheral sites. He described four

consequences of ‘wind-up’ (Woolf, 1994) as pain being evoked by non-noxious stimulus, a greater sensation of pain being felt when the stimulation is noxious, the duration of the pain sensation being prolonged and a wider area of the peripheral site becoming sensitised to painful stimulus.

There is a strong relationship between the effects of peripheral and central sensitivity and it is frequently difficult to tease the two apart in clinical and research settings. A collective term can be used to describe hyperalgesia, allodynia and the effects of ‘wind-up’: hypersensitivity.

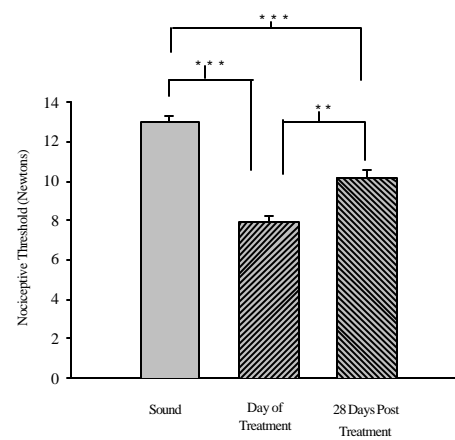
### Measurement of pain

As pain is both a physiological and an emotional state it is not considered possible to measure pain directly in animals, as we do not have sufficient insight into their emotional state. For this reason we rely on behavioural observation and measurable physiological effects of the pain process.

Clinically, the recognition of pain relies on signs of dull, depressed appearance, inappetence, weight loss, sudden drop in milk yield and rapid, shallow respiration (Sandford *et al.*, 1986; Loeffler, 1984). Rigidity of posture and immobilisation of painful areas can be signs of regional pain including lameness. In addition the common changes in posture such as transference of weight to a specific region of the claw and consequent limping may be useful indicators of lameness pain. These types of observation are invaluable in the detection of pain in animals. However, the limitation of this type of observation alone is that many of these signs are just those that are actively concealed by cattle and sheep as a survival strategy.

A research tool used in the study of hypersensitisation and the efficacy of analgesics is nociceptive threshold testing. The principal of the nociceptive test is to apply a controlled noxious stimulus (mechanical, thermal, electrical or chemical) to an area of the body. In a hypersensitised individual the point at which a response is elicited would be earlier than in an individual who does not have an increased sensitivity to noxious stimuli. The response to the test is termed the nociceptive threshold and a reduction in the threshold indicates hypersensitivity.

A study of lame cattle found that when compared to group of sound animals their threshold to a resolution of the lesions had been achieved (Whay *et al.*, 1998<sup>a</sup>). This demonstrates that it is not only the increased sensitivity to noxious stimuli, such as slipping and falling and bumping into protruding objects which can be found in every day life, but the persistence of this effect over time which contributes to the level of suffering. The results from this study are illustrated in figure 2. A similar result was recorded in sheep by Ley *et al.* (1995) when the nociceptive threshold of lame sheep was found to be reduced a month after treatment of foot rot lesions.



**Figure 2.** Mechanical nociceptive threshold of sound and lame dairy cattle, recorded on the day of treatment and repeated 28 days later.

mechanical nociceptive stimulus was considerably and significantly reduced, indicating hypersensitivity, when compared to the sound individuals. Not only was a reduced nociceptive threshold recorded on the day lameness was observed but also 28 days after treatment of the lameness lesions when apparent clinical

### **The management of pain associated with lameness**

*The management of pain associated with lameness in cattle can be divided into four phases. The importance of each of these phases is in their contribution to controlling the onset and magnitude of hypersensitivity.*

- a) **Recognition of lameness:** Early detection of lameness is pivotal to all subsequent action to relieve suffering.
- b) **Treatment:** Only rapid, effective treatment will permanently remove the persistent noxious input that results in hypersensitivity.
- c) **Sympathetic care:** Providing an environment that offers the cow the greatest chance to make a full and quick recovery.
- d) **Analgesia:** Drugs that can be manipulated to give immediate pain relief and to reduce the effects of hypersensitisation.

### **Recognition of lameness**

Recent evidence (Whay *et al.*, 2002) has shown that, certainly in the UK, farmers and stockpersons have a poor awareness of the level of lameness among their dairy cattle. This results in a failure to identify lame animals with a view to examination and treatment. There is evidence that the processes leading to hypersensitisation are switched on even in cattle showing only mild signs of lameness (Whay *et al.*, 1998<sup>a</sup>). This means identification of lameness and examination should not be limited only to those animals showing signs of severe lameness. Further more, identification of lameness should not be confined only to the individual but also directed at general changes in the locomotion of the whole herd. This would indicate where herd wide problems were developing e.g. dietary imbalances or outbreaks of digital dermatitis. Although many lameness lesions develop slowly allowing a prolonged period for the development of a hypersensitised state, timely intervention with a comprehensive pain management programme will contribute to reducing the intensity and duration of the effects of hypersensitisation.

### **Treatment**

There is evidence that different lameness lesions result in different levels of hypersensitivity (Whay *et al.*, 1998<sup>a</sup>). Cattle with chronic, slow developing lameness lesions such as sole ulcer and white line disease demonstrated a similar level of hypersensitivity 28 days after treatment as they did on the day of initial examination. In contrast, cattle with lameness due to infection of the digital tissue manifesting either as foul in the foot (*interdigital necrobacillosis*) or digital dermatitis had lowered nociceptive thresholds on the day of examination but this did not persist through to the next examination 28 days later. Digital tissue lesions are rapid in onset and can be rapidly and effectively treated in comparison to lesions such as sole ulcer and white line disease. This highlights the value of rapid and successful treatment in reducing chronic hypersensitivity.

Speed of recovery from a lameness episode has an important role in the management of hypersensitivity. Following treatment of lesions such as sole ulcer or white line disease the

animal must continue to function within the herd, bearing weight on the treated claw. This means that for a while after treatment the neurones in the area of the lesion will continue to signal that injury has occurred so sustaining wind-up and ultimately the duration of the period of hypersensitivity. The use of blocks applied to the sound claw, in situations where this is possible, will contribute to controlling this barrage of noxious input. At this stage sympathetic care and the use of analgesics become useful tools in the suppression of this noxious input.

### **Sympathetic Care**

This really has to be given by the stockman who takes over responsibility for the animals care and recovery once treatment is given. The cow's life may be made easier in order to facilitate recovery and to prevent unnecessary suffering in a number of ways. Provision of a soft, straw bedded loose box, with plenty of space for the cow to lie down and stand up without struggling. Access to feed and water without the need to walk far or to compete with the rest of the herd. Minimising the distance the cow has to walk to the milking parlour and providing a non-slip, even walking surface. Avoiding broken concrete and steep slopes and ramps that present a considerable challenge to the lame animal often resulting in slipping and falling. Consideration by the stockperson(s) in allowing the animal to walk at her own speed and to make allowances for abnormal behaviours in the parlour will also help the cow. These concessions made to the cow will often greatly reduce her suffering and improve her speed of recovery while limiting the further development of hypersensitisation during this time.

### **Analgesia**

Analgesics have a number of roles to perform in cattle medicine. They can provide immediate relatively short-term relief from acute pain. They can have a function in controlling and reducing the long-term effects of the pain state brought about by hypersensitisation. In addition, many of the drugs available for pain relief in cattle have actions other than only providing analgesia. Non steroidal anti-inflammatory drugs (NSAIDs) have anti-inflammatory and anti-pyretic actions in addition to their analgesic activity.

As cattle are food producing animals the drugs available for use as analgesics are restricted by licencing regulations, this means that the availability of drugs and who has access to them can vary greatly between countries. Further, the use of analgesics can be restricted by their prohibitive expense. The classes of drug that have analgesic activity suitable for cattle include local anaesthetic, NSAIDs, alpha-2 adrenoreceptor agonists, partial opioid agonists and anaesthetic induction agents.

A study of sensitisation as a result of surgical pain found that pre-emptive analgesia markedly reduced post-operative hypersensitivity in rats (Lascelles *et al.*, 1995). With a condition such as lameness it is not possible to initiate pre-emptive analgesia as the cow is only treated once signs of lameness become observable. Local anaesthetic is used to cause insensibility to a specific region of the body for a relatively short period of time. In general the local anaesthetic effect lasts from one hour up to 90 minutes if it is potentiated with adrenaline. This potent effect is often underrated. During treatment local anaesthetic not only allows better access to the claws but cuts off the noxious input from the lesion when it is likely to be most acute, i.e. during treatment.

Non-steroidal anti-inflammatory drugs are aspirin like drugs and are the most commonly available class of analgesic available for use in cattle. The NSAIDs act primarily through the inhibition of the enzyme cyclo-oxygenase (COX-1 and COX-2), which in turn results in the inhibition of prostaglandins and thromboxane which are known mediators of pain. In general, most of the commonly available NSAIDs are non specific in their COX inhibition, it is however only COX-2 which synthesises prostaglandin and therefore needs inhibiting. COX-1 has protective functions within the body and future development of this class of drug aims to avoid the unwanted inhibition of COX-1. The efficacy of the NSAID ketoprofen was demonstrated by Whay *et al.* (1998<sup>b</sup>). In a controlled study, lame cows were given a three day course of ketoprofen as part of their treatment regimen. These animals showed a reduction in their level of hypersensitivity at 3, 8 and 28 days after treatment when compared with a control group. The hypersensitivity was not abolished altogether but there was evidence of its modulation. A similar result was demonstrated by Fitzpatrick *et al.* (1999) using the NSAID flunixin meglumine during the treatment of mastitis in dairy cattle.

Alpha-2 adrenoreceptor agonists such as xylazine have a primary role as a sedative, they do however have effective but short term analgesic properties. The drug functions on the alpha-2 adrenoreceptors which are situated at pre and post synaptic sites on noradrenergic neurones. The alpha-2 adrenoreceptor agonists are known to have a range of side effects relating to the cardiovascular system.

A partial opioid agonist butorphanol has been used as part of a treatment programme for calves with infected joints. This class of drug has potent analgesic efficacy but due to its selective inhibition of opioid receptors can produce a range of unwanted side effects, including vocalisation and increased locomotor activity which is not desirable in an animal recovering from lameness.

Finally, ketamine hydrochloride is a very interesting drug, it is used as an anaesthetic induction agent. It functions as an antagonist of the n-methyl-d-aspartate (NMDA) receptors. NMDA receptors are involved in the spinal transmission of pain signals. Interruption of the function of the NMDA receptors results in an interruption of the wind-up process and consequently central component of hypersensitisation. Currently there is considerable research into developing new drugs that have NMDA receptor antagonistic activity.

## **Discussion**

The armoury for the management of pain associated with lameness in cattle is not sophisticated by the standards of companion animals. There are however a whole series of steps which can be taken to control the development and magnitude of hypersensitivity. It is, arguably, this process leading to chronic suffering, which should be our greatest source of concern.

At this stage it is difficult to quantify the actual contribution each step makes in reducing suffering. Many steps are inter-linked and would not be sufficiently effective in isolation. There is always a temptation to try to rely on analgesic drugs without tackling the underlying problems and adjusting the management of the animals involved. Many of the analgesics listed above have short-term activity and are only suitable short-term use. Drugs of this type, partial opioid agonists and alpha-2 adrenoreceptor agonists, are ideally suited to acute pain management. There

is evidence that NSAIDs contribute to the modulation of hypersensitivity and in the future drugs with NMDA antagonistic activity will, hopefully, have a role in the control of chronic pain. However, valuable as analgesics are they constitute only one part of a whole cow approach to pain management.

The most important step in the controlling pain is the prevention of lameness itself, this is the ultimate goal of lameness research. In the mean time it is not a question of whether a farm sees only one lame cow a year or finds that half the herd frequently suffers lameness. Lameness should not be seen merely as an inconvenience for the stockperson but a source of genuine and prolonged suffering to the animal and be dealt with as such.

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