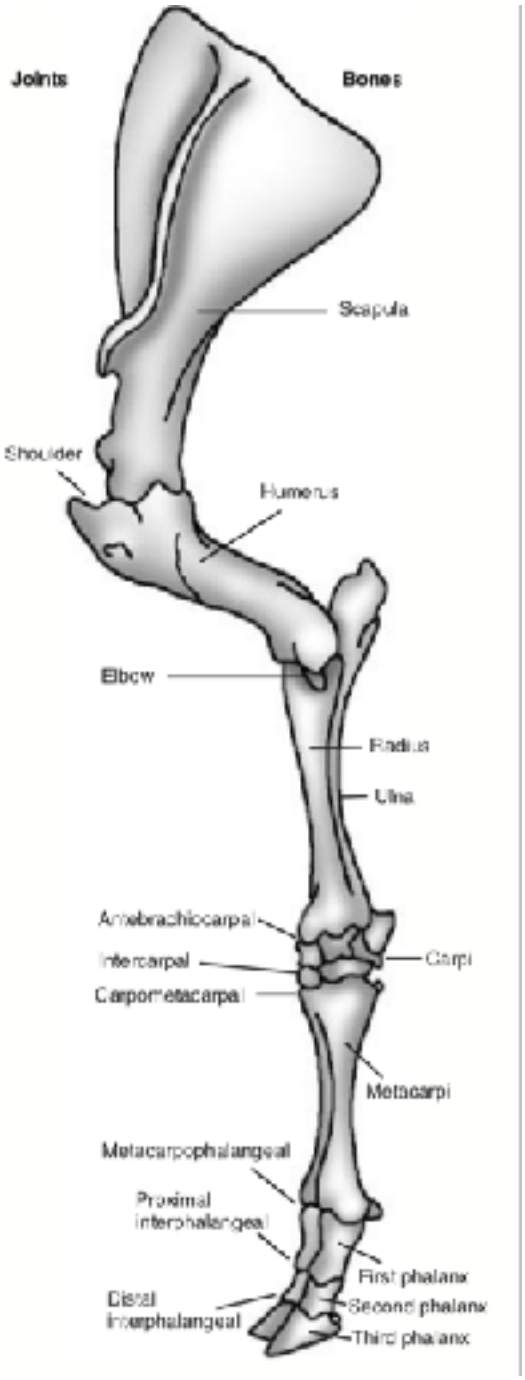
Anatomy The foot



The distal limb is composed of four digits that are numbered from medial to lateral as second, third, fourth, and fifth. Only two of these are weight bearing (third and fourth). It comprises two digits each of which has a horn-covered claw. The foot includes the limb below the fetlock joint. Each digit of the foot consists of three phalanges (proximal, middle, and distal or P_1, P_2, and P_3; and the navicular bone (distal sesamoid) and two joints— proximal interphalangeal (PIP) joint and distal interphalangeal (DIP) joint. P_1 is longer than P_2 . Little longitudinal growth occurs in P_1 after birth. P_1 has a distinct marrow cavity. The palmar or plantar pouch of the PIP joint is situated deep to the terminal portion of the superficial digital flexor tendon (SFT). Care must be taken not to open this pouch during surgical procedures requiring resection of the SFT. Collateral ligaments and a palmar/ plantar ligament support the PIP joint. P_3 is completely enclosed within the claw horn capsule. Its solar surface is concave. The deep flexor tendon is attached to the flexor tuberosity at the back of P_3.

The navicular bone is attached to P_3 by three small distal ligaments and is also attached to P_2 by two collateral ligaments. The navicular bursa is situated between the navicular bone and the deep flexor tendon and permits movement of the deep flexor tendon over the surface of the navicular bone during extension and flexion of the claw.

Lateral and medial digits are connected by proximal and distal cruciate ligaments. The proximal cruciate ligament is situated at the proximal extremities of both the proximal phalanges. The distal cruciate ligament is wider and more superficial than the proximal cruciate ligament and lies just above the palmar/plantar interdigital cleft. The origin of the distal cruciate ligament is at the distal aspect of the proximal phalanx. The ligament continues superficial to the deep flexor tendon and inserts on the axial surface of the navicular bone and P_3. The insertion of the distal cruciate ligament forms a significant part of the structure of the suspensory system of the caudal aspect of P_3 with some of its fibers also running into the deep digital flexor tendon.

CLINICAL EXAMINATION OF THE HOOF

Restraint

Physical restraint that ensures the safety of the clinician and patient is essential for detailed examination of the foot. Ideally a crush designed for foot work, or a foot trimming flip table should be used. However, basic crushes, AI stalls and swing gates can be used to good effect in combination with competent and judicious usage of roping techniques. Casting with ropes with the use of hobbles and/or chemical restraint using sedation can be helpful in extreme circumstances, but it is often difficult to control small forceful movements. Intravenous regional anaesthesia should be considered in patients with very painful conditions to enable thorough exploration and detailed examination, particularly where aggressive paring may be required.

Close inspection of the standing animal

Following restraint, the use of a hosepipe to remove gross contamination of the foot may be necessary. Gross lesions on the anterior aspect of the foot are easier to visualise before raising the leg.

Horizontal and vertical fissures of the hoof wall – a horizontal fissure that has progressed to the toe may cause a piece of the toe horn to snap off prematurely resulting in a ‘broken toe’

Coronary band lesions – may be caused by digital dermatitis or trauma.

Severe swelling of the area proximal to the coronary band – may indicate a septic arthritis of the distal inter- phalangeal joint or ascending infection from white line disease.

Coronary band vesicles/erosions – if foot-and-mouth disease is suspected, a careful examination for vesicles or ruptured vesicles is required; if mucosal disease is suspected, erosions may be present.

Grossly overgrown and corkscrew claws – will be self evident.

Examination of the foot

Interdigital space

The interdigital space can be examined by gently parting the claws.A pen-torch can facilitate the search as the examination area is often poorly lit. Stones or other foreign bodies may be lodged here and can easily be missed . Interdigital hyperplasia may be seen, particularly in the hind feet, and presents as a ridge of solid tissue which may force the claws apart (Fig. 13.4). The skin between the claws should be checked for integrity. Foul in the foot causes skin necrosis and a characteristic unpleasant odour (Figs 13.6 and 13.9). Puncture wounds caused by foreign objects may be seen in the interdigital skin, and if chronic the wound may be granulating. The wound may be associated with a septic distal inter- phalangeal joint

Bulbs of the heel

The bulbs of the heel should be carefully inspected for erosion of the heel horn which is often called slurry heel. This condition often produces a dark or tarry appearance with deep furrowing and fraying of the softer horn of the heel. A painful swelling of the heel, with or without a sinus tract, is usually indicative of infection tracking from an entry point at the white line towards the back of the sole. Haematoma of the heel may produce a discrete swelling of the bulbs of the heel. Lesions caused by digital dematitis are commonly found on the skin between the bulbs of the heels and are recognised as a raw shiny area of skin with the shape and colour of a strawberry cut in half (‘strawberry heel). The lesion is very painful when touched.

Swelling of the skin around the distal limb

Foul presents as a swelling of skin between heels and accessory digits caused by inflammation of the shin and subcutaneous tissue. The claws may be forced apart with necrotic interdigital skin]. Infection of the synovial structures of the distal limb including the distal and proximal interphalangeal joints, results in severe generalised swelling of the distal limb.

Examination of the sole

Corrective foot trimming using the Dutch five-step method is a useful starting point to examine conditions of the sole, as initial examination without corrective trimming can lead to a misdiagnosis and unjustified invasive paring. In the correctly shaped foot, weight is taken on the heel and the wall with the exception of the middle one-third of the axial wall (no white line) (Fig. 13.13). Overgrowth of the toe leads to backward rotation of the pedal bone towards the heel. Erosion of the heel can exacerbate the degree of rotation. Rotation can cause corium pinching between the pedal bone and the hoof.

During corrective foot trimming when the sole has been reduced to the correct thickness, the condition of double sole may have been identified as a layer of poor quality dark flaky horn sandwiched between normal solar horn as the depth of sole was reduced. This reflects an historical period of poor horn production and may coincide with a bout of laminitis. Small flat stones and (particularly) shards of flint can sometimes be deeply embedded in the sole and will have been identified at this stage (Fig. 13.8).

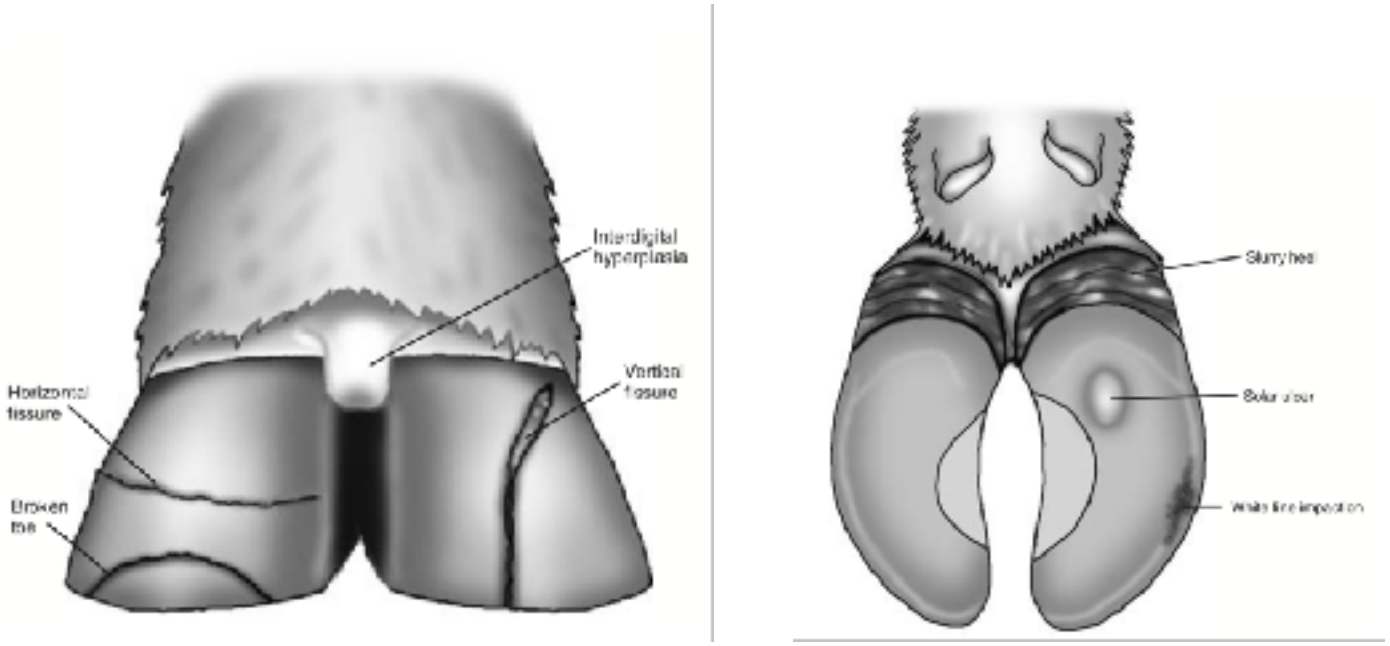
Once the shape and thickness of the sole has been corrected, problem areas of the sole can be recognised and investigated. The sole of the hoof is often pigmented. These discrete pigmented areas should not be mistaken for abnormality.

Bruised sole The sole may be worn thin from walk- ing over hard rough surfaces and is easily bruised. Bleeding occurs beneath the sole. The condition is painful on compression of the sole.

Classical solar ulcers These are recognised as circumscribed areas where horn is missing or the horn is of very poor quality. The corium is exposed or has been protected by the production of granulation tis- sue. The ulcers occur towards the back of the sole, two-thirds of the distance between the toe and the heel directly over the posterior border of the pedal bone.. Less commonly *solar heel ulcers* may be present which are set further back on the sole. Ulcers are often bloody due to presence of granulation tissue, and very painful.

White line disease The white line is a point of weak- ness, and dirt may become impacted and provide a portal of entry for infection if the integrity of the join between the horn of the wall and the horn of the sole is compromised. Once the claw has been trimmed affected regions of the white line can be readily identified as distinct black thick zones

Solar abscess White line disease can result in ascending infections or lateral infections. The latter produce solar abcesses. These may be detected during corrective trimming by a sudden thinning of the sole followed by the appearance and drainage of pus. Alternatively, it may present as a painful pliable thin sole at the end of Stage 1b of the foot trimming process. Pain testers can be useful to localise the area of pain, and further thinning of the sole may punc- ture the abscess. Occasionally, on applying pressure, pus can be seen to exude from the original portal of entry in the white line.



Biomechanics of weight (load) bearing

Biomechanical stresses along with calving and primary laminitis are regarded as playing a major role in the pathogenesis of lameness.

Biomechanics relates to weight-bearing dynamics within and between claws and is usually expressed as total, maximum, or average weight bearing. Total weight bearing or vertical force includes the total weight carried on both claws. The distribution (balance) of weight bearing between claws is variable depending on location (front or back legs), age, and weight.

Weight bearing of the rear claws

Weight bearing between claws

Research has shown that the outer claw of the hind leg carries more weight relative to the inner claw (Figure 4.1). The asymmetry in weight bearing is associated with increasing weight and/or age (Figure 4.2). One study found weight distribution between the outer and inner claw of the hind leg to be 80:20 in slightly overgrown claws, which changed to 70:30 following trimming and "balancing" of the heels. Using cows with overgrown claws, another study found the outer claw of the hind leg carry 68% of the total weight (vertical force) and the inner claw 32%. Following functional claw trimming the same study found that total weight was reduced to 52% in the outer claws and increased to 48% in the inner claws. A third study, in which cows were used with slightly overgrown feet, found that the highest load was carried on the outer claw irrespective of trimming. Based on the above, it seems clear that functional claw trimming is important in redistribution and balancing of weight bearing between the outer and inner claw of the hind leg.

The mechanism of the rear claw imbalance in weight bearing relates to the animal's normal skeletal structure, which in the back legs is fairly inflexible with the femur (and thus the rest of the leg) being attached to the bony pelvis through the hip joint.

Weight bearing of the front claws

There is more even weight distribution between claws of the front legs because attachment to the chest is by means of different muscle groups, thus providing more flexibility. Maximum pressure also occurs at the sole heel area. In general the inner claw bears more weight as compared to the outer claw.

Feet and leg traits

The heritability of certain feet and leg traits is high enough to achieve a genetic response such as hock angle (rear leg side view) and screw claw. However, nutritional and management factors may also have a pronounced effect.

Claw volume

Claw volume may also play a role in the pathogenesis of lameness. Increased claw volume may reduce lameness risk based on better shock absorption capabilities. Volume of front claws has been

shown to be larger than those of rear claws. There is a tendency toward symmetry in claw volume in diagonally opposed limbs.

Walking surface

Hard walking surfaces in association with normal weight-bearing dynamics have been associated with claw/heel overgrowth, particularly of the outer rear claw including sole overgrowth in the typical place of sole ulcer development.

Frictional properties of floor surface will result in altered weight-bearing dynamics. On smooth surfaces, slipping is prevented with rapid short steps with upper limb held more vertical and joint arcs reduced. Walking surfaces with larger aggregates decrease speed and step frequency, resulting in longer steps. Limbs are held vertical to reduce the supporting limb phase.

Cow comfort

Problems related to other cow comfort issues such as reduced lying down time, inadequate housing, or poor stockmanship could present additional biomechanical stress. These stresses singly or in combination can lead to alterations in weight-bearing dynamics, which in turn may lead to the development of claw horn lesions, changes in claw shape, conformation, and lameness.

Claw trimming procedures Introduction

The normal weight-bearing area of the claw includes the heel, wall, and the white line as well as the sole. The abaxial wall is weight bearing along its entire length, while the axial wall and white line is

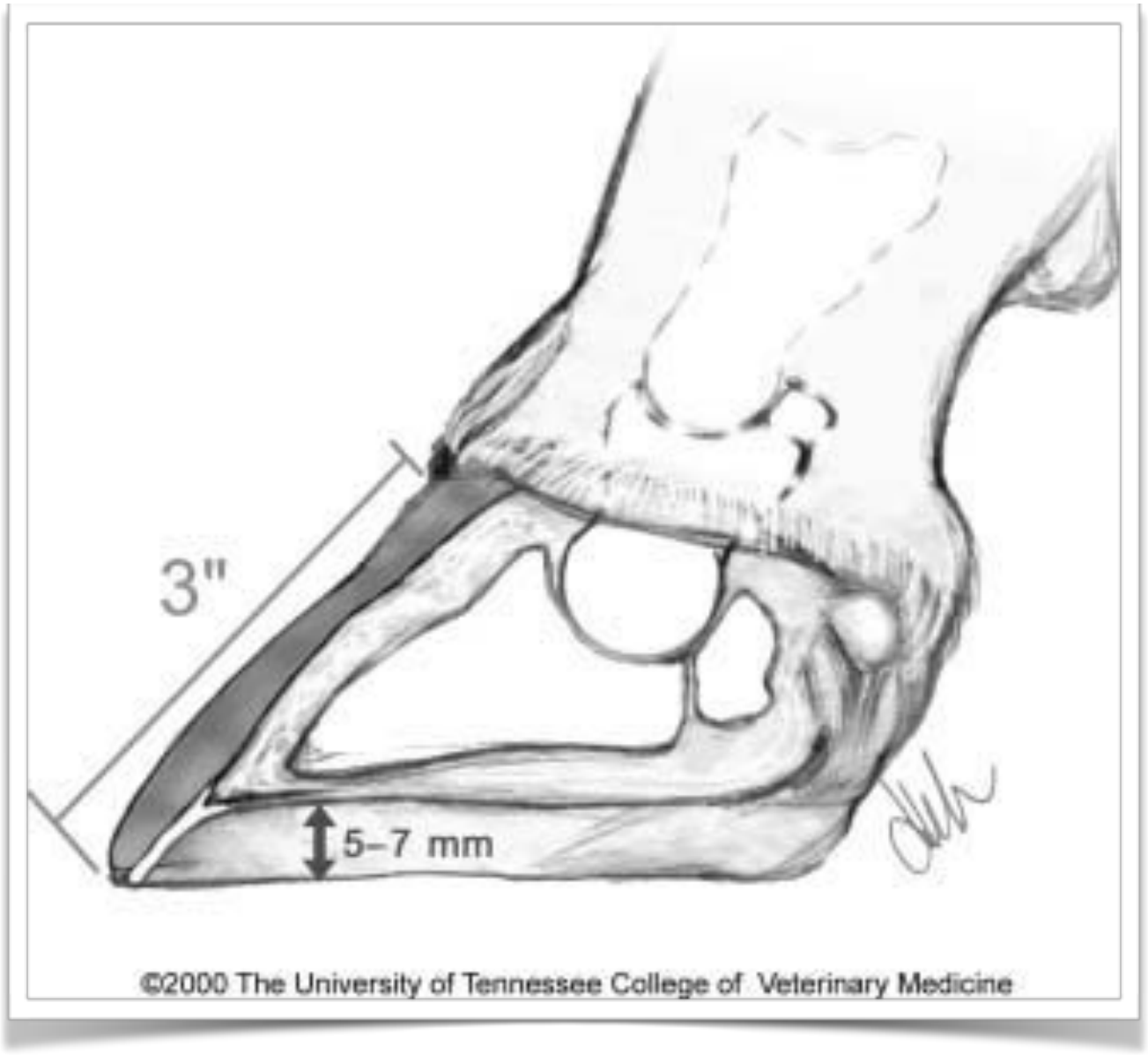
only weight bearing for a short distance to where they diverge proximally in the interdigital space (Figure 2.9).

The sole is weight bearing along its entire surface except the inner most back portion at the interdigital space, where it is sloped (Figure 4.5). In beef cattle the sole is more sloped than in dairy cattle due to the fact that the wall is harder than the sole and wears less on dirt. In dairy cattle a more flat bearing surface is created by mechanical wear on concrete walking surfaces. Force plate studies have shown that after trimming the sole flat, there was a significant increase in weight-bearing contact surface on both claws, while at the same time average pressure within the claw was significantly decreased.

A sole that is made to slope excessively toward the interdigital space could also place greater mechanical stress on the abaxial white line and the interdigital structures. However, a normal slope in the sole is desirable in order to (a) open the interdigital space, thus limiting manure entrapment in the interdigital space and (b) relieve pressure from the sole ulcer site.

There is a difference in the weight-bearing dynamics between the outer and inner claw of the hind leg: (a) The axial part of the heel of the inside claw is less developed than the corresponding area of the outer claw. Thus the heel of the inner claw has a smaller weight-bearing surface .The axial weight-bearing area of the wall and white line extend over a shorter distance on the inner claw (Figure 2.9). Overall the inner claw thus has a smaller supporting surface that makes it less stable. This instability of the inner claw on hard surfaces is further increased by the normal slope and concavity of that claw. This instability of weight bearing within the inner claw particularly at the heel is probably the reason why most of the pressure during the first part of the stride is centered in the heel and abaxial heel/wall/sole junction of the outer claw. This results in significant overgrowth of that heel, thus creating further instability. Balancing the heels during any functional trimming procedure would therefore be an important consideration. Overgrowth of the toe particularly on nonabrasive surfaces occurs since the horn of the wall at the toe is harder and more resistant to wear as compared to the heel. This may move more of the weight-bearing pressure toward the heel, which potentially could cause compression and injury of the solar corium between the flexor tuberosity of the third phalanx and the sole (Figure 4.7). Correcting toe length and sole thickness at the toe is another important consideration during routine trimming procedures

THE IDEAL HOOF CONFORMATION



A dorsal wall length of 3 in. (7.5 cm) which correlates to a sole thickness of 0.25 in. (5–7 mm) 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 to provide sufficient sole protection to the corium

Soles should be of equal height along the entire length of the hoof to facilitate even weight bearing distribution

Heel bulbs should be of equal height to facilitate even weight bearing distribution

Modelling of the axial surfaces of the hoof wall to facilitate interdigital cleft to activate the self cleaning mechanism of the hoof