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Popular Article

Functional Anatomy of Hoof in Horses

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Abstract

The quote "no hoof, no horse is entirely true. Without solid, sound feet, you have no horse, so understanding hoof anatomy is extremely important. The hoof of horse is anatomically complex designed and highly specialized digital end organ. Compare the size and weight of a horse relative to the size of a hoof, and how fast horses can run or how high they can jump; it's amazing how so much is supported by so little. Knowledge of functional anatomy of the hoof and all its internal structures is of paramount importance in being able to assess the condition of the horse health and performance. The different parts of hoof serving a different purpose, yet working in symmetry to keep the horse sound and healthy. Numerous factors can affect hoof structure and health, including genetics, hoof conformation, environmental influences, and athletic performance of the animal.

Introduction

The interaction of human and horse is well known for sport competitions and non-competitive recreational pursuits, agriculture, police work and entertainment. Horses were historically used in warfare, from which a wide variety of riding and driving techniques developed. Humans provide domesticated horses with food, water, and shelter, as well as attention from specialists such as veterinarians and farriers. A hoof plays a major role in its ability to survive and function. Hooves perform many functions, including supporting the weight of animal, dissipating the energy impact as the hooves strike the ground, protecting the tissues and bone within the hoof, and providing traction for the animal. Horse's hooves not only require daily cleaning, but some horses benefit from shoeing as well. Horse's hooves are subjected to many insults either out in the pasture or while they are being ridden or driven. Stone bruises, punctures, and abscesses are all common problems in equine hooves. Horses also suffer from diseases similar to those in cattle, sheep, and goats. Understanding the functional anatomy of the horse hoof is essential in order to further investigate the structures involvement in the pathogenesis of lameness and in order to help understand disorders such as lameness and laminitis.

All four hooves of a horse are structurally designed the same. The Hoof is the horny covering of the distal end of the digit. For description it is divided into external structures such as wall, sole and frog, and internal structures as digital cushion and bones.

(A) Wall of Hoof

The hoof wall can either be black or white. While there is some belief that black hooves are stronger than white hooves, that's just a myth. Farriers confirmed that the quality of the hoof is not affected by its colour**.** The wall is hard, horny outer covering that house and protects the more delicate structures within, supports the weight of the horse and absorbs shock as the horse moves (Fig.1). It covers the front and sides of the foot, and is reflected posteriorly at an acute angle to form the bars (Fig.2). Hoof wall does not have blood vessels and nerves. It is a continually growing, keratinous material that needs to be trimmed or naturally worn off. A healthy hoof wall grows about 3/8 of an inch per month; 5/16 of an inch (8 mm) every month. Hoof wall can either be black or white. The primary purpose of the outer wall is store and release energy during the different phases of the stride to help propel the horse. It also provides protection from the structures within, regulating ingress and egress of moisture. Healthy wall should not have any cracks or rings. Cracks can make the internal structures vulnerable to potentially damaging substances, like gravel or germs. Rings on wall can indicate that the horse may have some additional health problems that are affecting his hooves.

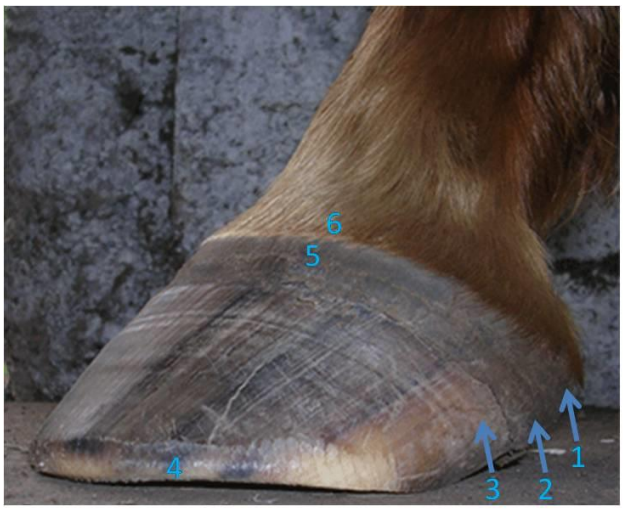

Fig.1 Hoof wall showing 1. Heel bulb, 2. Heel, 3. Quarter 4. Toe 5. Periople 6. Coronary border

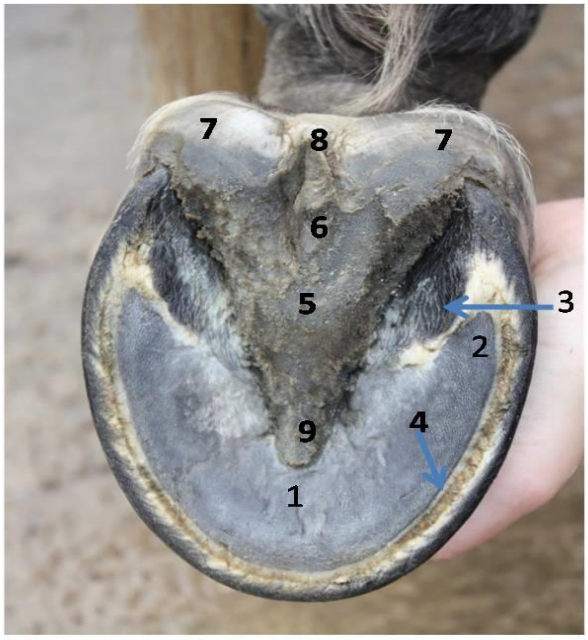

Fig.2 Hoof (ground surface) showing 1. ole, 2. crura 3. bar ,4. white line, 5. frog 6. central sulcus 7. bulb 8. base of frog and 9. apex of frog.

The different parts of wall are following

1. Toe: Most anterior part of the wall (Fig.1).
2. Quarter: Medial and lateral parts of the wall (Fig.1)
3. Heel: Angles of the wall (Fig.1).

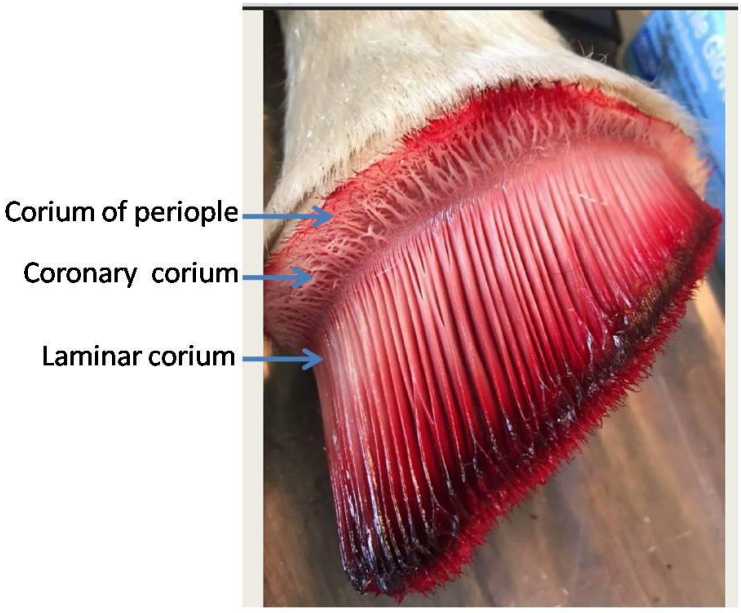

Fig.3 Internal view of hoof after removal of hoof wall and part of skin showing

The thickness of wall at the toe, quarter and heel is about in the ratio of 4:3:2 for the fore foot and about 3: $2^{1/2}$:2 for the hind foot. For description the wall has 2 surfaces and 2 borders:

a. **External surface**: it is convex from side to side and slopes obliquely from edge to edge. Angle of inclination to the ground on the front of the hoof. In forelimb- 50 degree, in hind limb is 55-degree angle of inclination to the ground on the heel is 100 degrees.

b. Internal surface: it is concave from side to side and bears about six hundred thin primary laminae which extends from coronary groove to the basal border of the wall (Fig.4). Each primary laminae bears a more than hundred secondary laminae, so that the arrangement is pinnate on cross scetion. Laminae are continued on the inner surface of the bars and dovetail with corresponding laminae of the corium (Fig.3).

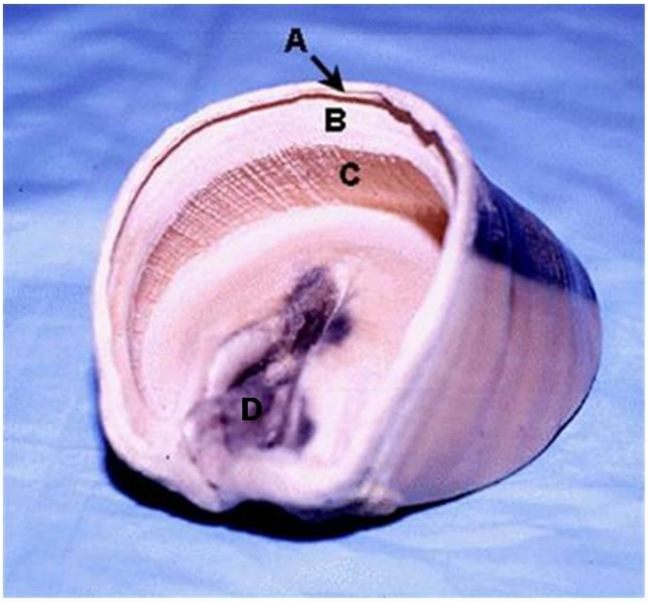

Fig.4 Showing (internal surface) A. coronary groove, B.perioplic groove ,C. laminae of wall and D. frog stay

Borders

a. Coronary border: it is thin and covered by a layer of soft, light-colored horn known as the periople; this appears as a ring like prominence above and gradually fades out below; at the angle it forms a wide cap or bulb and blends centrally with the frog (Fig.1). The inner aspect of

the border is excavated to form the coronary groove, which contains the thick coronary corium (Fig.4). The groove narrows on the sides and merges at the angles with perioplic groove (Fig.4).

Periople: The outer aspect of cornary border covered by a layer of soft, light-colored horn (Fig.1). This is known as periople of the hoof. The soft area is made up of newly formed hoof wall tissue, and the periople helps give it time to harden.

b. Basal border/ Ground border: It comes in contact with the ground. Its thickness is greatest in front and decreases considerably with on before backward on either sides but there is slight increase at the angles. Its inner surface is united with the periphery of the sole by horn of lighter color and softer texture, which appears on the ground surface of the hoof called white line or white zone (Fig.2). White line is distinct line of demarcation between wall of hoof and sole and should take care of it when shoeing is done in horses.

(B) Sole

Sole forms the greater part of ground surface of the hoof (Fig.2). It is somewhat crescentic in outline and for description presents two surfaces and two borders.

Surfaces

a. External surface or ground surface: it is concave, curved more strongly in the hind than the fore foot. The curvature is more in lighter breeds than in heavy draft horses. The surface is usually rough, since the horn exfoliate here in irregular flakes.

b. Internal surface: it is convex and slopes obliquely downward to the convex border. It presents numerous small funnel like openings which contain numerous papillae of the sole corium in the natural state.

Borders

a. **Convex border:** it is joined to the wall by relatively soft horn called white line on the ground surface of hoof (Fig.2). The white line is somewhat yellow in color as discussed previously. White line is the junction between the hoof wall and the sole. Tissues of the white line area contribute to sole protection and help attach the sole to the inner wall of the hoof. When the white line area becomes impaired, it allows germs to enter and separate the layers of the hoof wall. Once this happens, it can spread throughout the hoof and make the horse lame.

b. **Concave border:** it is in the form of deep angle, which is occupied by the bars and the apex of frog (Fig.2). It concurs in part with these in forming two pronounced ridges in the interior of the

foot. The parts of the sole between the wall and bars are called crura (Fig.2). The palmer or planter extremity of crus is called angle of the sole.

(C) Frog

It is wedge shaped mass which occupies the angle bounded by bars and sole and extends below the ground surface of the foot (Fig.2). It protects the digital cushion beneath it, aids in traction and circulation in the hoof, and partly acts as a shock absorber when the horse moves. For description it has two surfaces, a base and an apex.

Surfaces

1. External surface or ground surface: it presents central sulcus, bounded by paired ridge like called crura. The medial and lateral surfaces are united at the upper part with the bars and sole
2. Internal surface: it bears central ridge called frog stay, which is high posteriorly but dorsally subsides abruptly in front (Fig.4). On either side of this there is depression, bounded outwardly by the rounded ridge formed by the junction of the frog with the bar and sole. The surface presents fine stria and openings for the papillae of corium.

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Base: It is depressed centrally and prominent at the sides where it unites with angles of the wall; the junction here is covered by the expanded periople and constitutes the bulb of the hoof (Fig.2).
Apex: it occupies the central angle of the concave border of the sole and form blunt rounded prominence a little dorsal to the middle of the ground surface of the hoof (Fig.2).

Corium of the foot or Pododerm

It is specially modified and highly vascular part of the corium of the common integument which furnishes nutrition to the hoof (Fig.3). It is divided into five parts which nourish corresponding parts of the hoof.

1. **Perioplic corium:** it gives nutrition to periople**.**
2. **Coronary corium:** it gives nutrition to bulk of wall of hoof.
3. **Laminar Corium:** it gives nutrition to horney lamellae and interlaminar horn of the white zone.
4. **Corium of sole:** it gives nutrition to horny sole.
5. **Corium of frog:** it gives nutrition to frog.

Vessels and nerves of hoof

The corium is richly supplied by digital arteries. The veins are valvless and form extensive plexuses which communicate with each other and are drained by the digital veins. The

lymph vessels form subpapillary plexuses in corium of sole and frog. The nerves are branches of the digital nerves.

Internal Structures

1. Digital cushion

It is wedge shaped mass which overlies the frog (Fig.). For description it presents four surfaces, a base and an apex. The superficial surface covered by corium of frog. The sides are related chiefly to the cartilages of the distal phalanx or coffine bone. The deep surface of cushion is connected with the distal fibrous sheath of the deep digital flexor tendon. The base is situated caudally and presents two prominences termed bulb of cushion. The apex is adherent to the terminal part of deep digital flexor tendon (Fig.5)**.** The digital cushion is poorly supplies with vessels. It consists of white and elastic fibres, in meshes of which are masses of fat and some islands of cartilage. The bulbs are soft and contain more fat. The coiled glands occur chiefly in the part which overlies central ridge of frog and their secretion contains fat. Horses with a long toe, low-heel conformation may have a compromised digital cushion, as the heels are load-bearing more weight than normal and it slowly compresses the cushion's thickness. Once the digital cushion is "crushed," it will not regenerate.

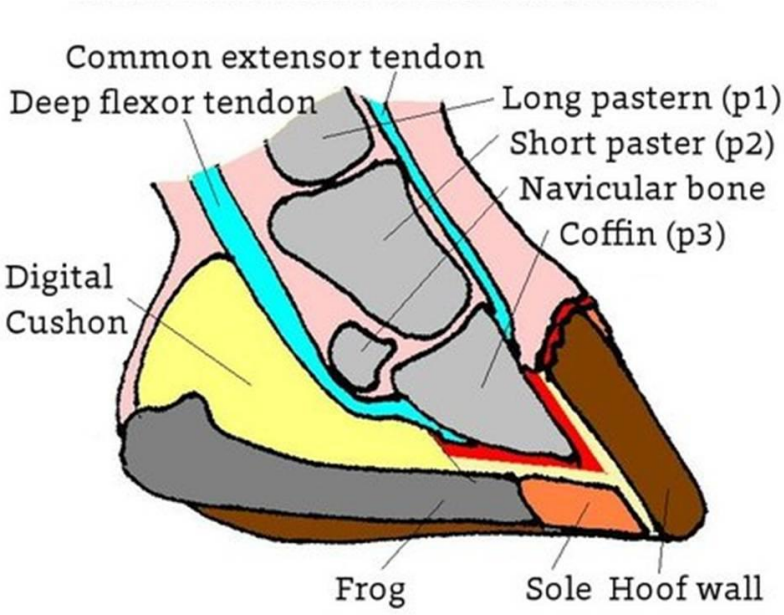

Fig.5 Showing different parts of hoof (lateral view)

2. Coffin Bone/ Pedal bone/IIIrd Phalanx

The coffin bone is encapsulated in the hoof (Fig.5). It is the largest bone in the hoof and helps to shape the hoof wall. It is surrounded by special tissues that make-up the laminae of the hoof wall, as well as, the tissues of the sole. Anything that upsets the working relationship between the coffin bone and the hoof capsule, such as major shoeing changes, sole puncture and rotation of the coffin bone, can result in lameness.

3. Navicular Bone/ Distal sesamoid bone

The navicular bone is the small bone that is tucked behind the coffin bone and the short pastern bone (Fig.5). The navicular bone helps to stabilize the coffin bone and allows for some

tilt over uneven ground. There are two major tendons that help support and move the bones the extensor tendon and the deep digital flexor tendon. The extensor tendon attaches to the front of the coffin bone and straightens the leg; whereas, the deep digital flexor tendon runs down the back of the leg and wraps around the navicular bone, bending and flexing the leg.

Hoof care and its management

Hoof care is an important issue for all horse owners. While a horse may be able to sustain injury or illness in many parts of its body, the hoof bears weight and so adds hundreds of pounds of stress to any ailment. Maintaining a healthy hoof is the best way to give horses a good shot at long, healthy lives. Regularly pick out your horse's hooves. The goal of picking out the hoof is to keep out rocks and thrush. A horse hoof grows continuously over time and need to be trimmed every six to eight weeks to keep them in proper shape. The hooves must also be balanced to the horse's natural way. Some common horse hoof problems as cracks, canker, bruished sole, thrush, abcess and overgrown hoof, that can be happen (Figs.6-11). So it is important to know what to

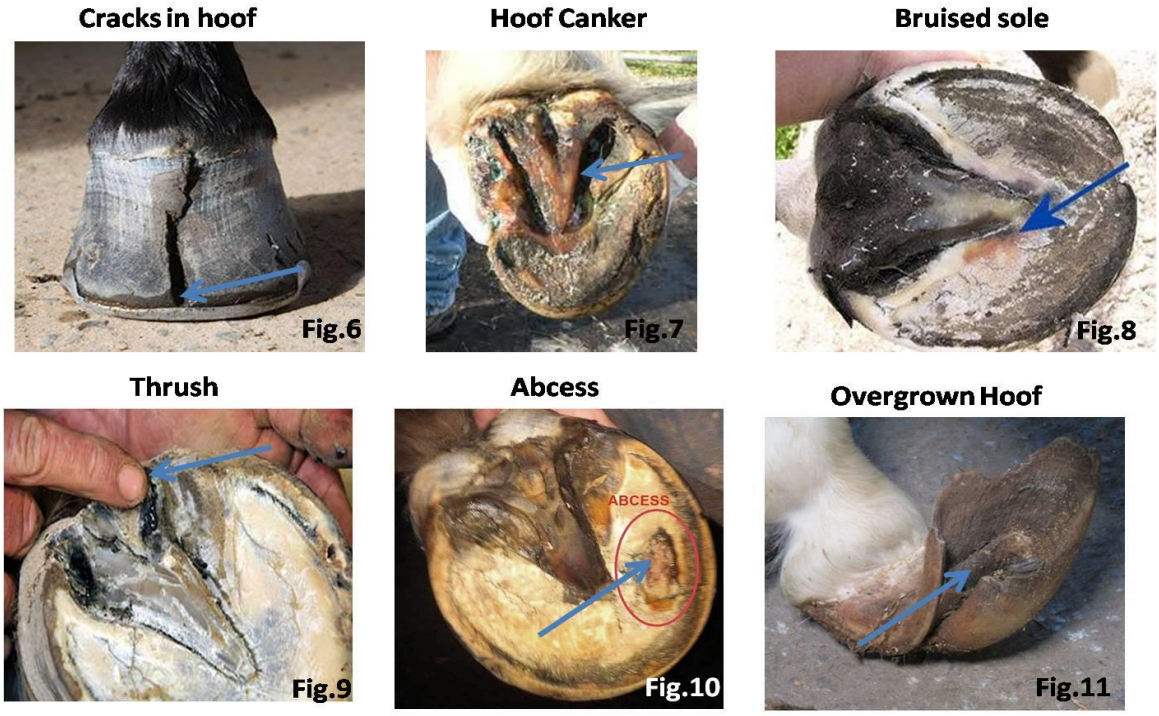

Fig.6–11 showing some common horse hoof problems

watch out for, and what to do in case a problem arises. This is why it is important to check your horse's hooves regularly. A horse is only as strong as the feet it stands on. Without a healthy hoof, a horse could be in trouble.

Horse Shoeing

Not every horse will require shoeing, but if your horses are doing a lot of hard work or working on hard surfaces, the horse will need to be shod. If a hoof is not maintained properly, it can cause problems such as cankers, bruised sole, abscesses, and cracks in the hoof wall. Horse shoe prevent the feet of horses from being worn down excessively. It also prevents hoof wall from proximally to the end of the horny wall at the coronary splitting. Horse shoe prevent slipping of feet. Shoe protects the foot from bruising. Shoeing achieves a balanced foot with normal axis. Horse shoeing keep the pastern and hoof axis unbroken. Shoeing reduces uneven concussion to the foot. Horse shoeing give better traction in unfavourable for shoeing & terrain. It also helps to cure hoof diseases & weight and hoof defects. Physiological horseshoeing could be defined as that which promotes a healthy functional foot, biomechanical efficiency and prevents lameness.

Conclusion

Functional anatomy of the hoof is helpful to understand how certain lamenesses occur, how to prevent them. In order to understand how to properly care for the hoof, it is important that understand the basic structure and anatomy of the hoof. The hoof is a complex structure that plays a key role in many aspects of the animal's overall health and productivity. Healthy hooves lead to healthy animals, which raises productivity and income. When hooves are kept in good condition, it reduces the losses that stem from treating lame animals and the production losses that result from their discomfort. A lame animal is not only in pain, but it is an extra expense that most producers cannot afford. By maintaining a sound hoof management routine, animal owners can reduce their economic losses and increase their chances for profit in the future.

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