Explaining Laminitis and its Prevention ©

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Chapter 1-The Normal Foot

Fig 1. Outer surface of the pedal bone, note how many holes or foraminae are present. In life, these contain arteries coming outwards from the terminal arch. The arteries nourish the laminar corium covering the outside of the pedal bone (see Fig. 2). There are no foraminae on the underside of the pedal bone (other than at the `wings').

The pedal bone is crescent shaped, (Fig. 1), the outer surface is covered by a soft tissue called corium (Fig. 2) . Corium is the same as the dermis or quick of your finger. Covering and nourished by the corium is the epidermis, the same as your skin or nails. In the horse's foot the corium is given the name of the epidermal or horny structure it supports. Thus there is perioplic corium, coronary corium, laminar corium, solar corium (sensitive sole) and frog corium (sensitive frog). At this stage it is helpful to get used to some of the terminology which has been used by other authors. Laminae are sometimes called lamellae.

Corium = Dermis = Quick = Sensitive.

Dermal laminae = Soft tissue laminae = Sensitive laminae = Laminar corium.

Epidermal laminae = Horny laminae = Insensitive laminae.

The whole weight of the horse is transmitted down the bones in the legs to the pedal bone at the bottom. The pedal bone, and thus the weight of the horse, is suspended inside the horny hoof capsule by the attachment between the dermal laminae and the epidermal laminae. There are about 600 laminae, the dermal and epidermal laminae interlock like slotting the fingers of your hands together. As the main function of the laminae is attachment of the pedal bone to the inside of the hoof capsule, it is not surprising that the surface area of the laminar corium is considerable (Figs. 3 & 4).
To increase still further the area of attachment, there are tiny surface corrugations covering the laminae (Fig. 5) .

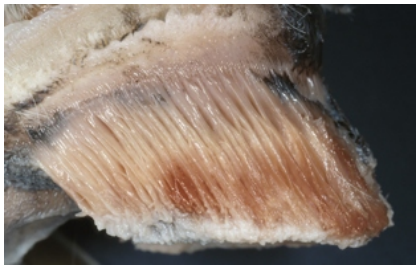

Figure 2. These are the dermal laminae which cover the pedal bone. Each dermal lamina slots in between two epidermal laminae.

Just as the laminar corium is specialised for attachment, so the coronary corium, which merges with the top of the laminar corium, is designed for the production of the bulk of the hoof wall. The coronary corium, instead of having leaf-like laminae over its surface, has thousands of tiny finger-like projections or papillae (Fig. 6) .

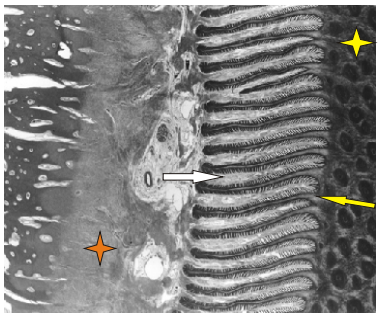

Figure 4. This is a transverse sectional view through the hoof wall as seen through the microscope. The pedal bone is on the left and the outside of the hoof is on the right. The pedal bone is covered by the connective tissue of the periosteum (orange star) which contains arteries, veins and nerves and merges with the dermal laminae (white arrow). The two sets of laminae, dermal and epidermal (yellow arrow) slot together like interlocking fingers. The tubular horn from the coronary papillae and the intertubular horn from the pits between the papillae are clearly visible making up the bulk of the hoof wall (yellow star). (Photo courtesy of Dr Susan Kempson).

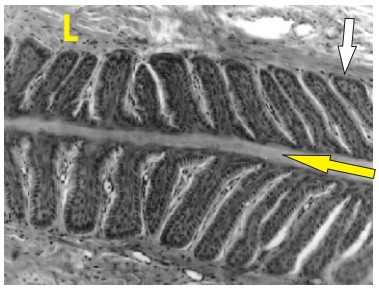

Figure 5. A higher magnification view of the interlocking dermal (L) and epidermal laminae (yellow arrow). Small blood vessels are seen within the dermal laminae. A thin lining membrane [the basement membrane] (white arrow) supports basal cells which produce the horny epidermal laminae. The basal cells divide to produce daughter cells which undergo keratinisation (become horny) to become the epidermal laminae which can be seen in Figure 3. (Photo courtesy of Dr Susan Kempson).

Figure 3. Covering the dermal laminae are the epidermal laminae and other horny structures which make up the hoof capsule. Above the the epidermal laminae is the coronary groove (white arrow) which contains the coronary corium.

Figure 6. Close up view of the coronary groove; the inside of the hoof capsule is at the bottom of the figure. Each hole contains one coronary papilla which is responsible for the growth of one horn tubule. At the inside edge of the coronary groove the arrangement of holes changes into sheet-like laminae at the top of the laminar

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Each coronary papilla is responsible for the production of one horn tubule which grows down to the ground. The tubular horn is separated by inter-tubular horn which grows from the pits between the coronary papillae. The bulk of the hoof wall, produced by the coronary corium, is designed for the protection of the internal structures, abrasion resistance and shock absorption (Figs. 4 & 7) .

Above the coronary corium, between it and the skin, is a narrow rim of perioplic corium. This produces a thin layer of softer tubular horn which grows over the juvenile coronary horn and offers a little protection against drying and abrasion (Fig. 7). Perioplic horn rarely extends more than about an inch down the hoof wall. Beyond this limit it is worn away by abrasion on grass or bedding.

The solar corium is attached to the bottom of the pedal bone in the front of the foot and to the under surface of the digital cushion in the back of the foot (Fig. 8). The solar corium is arranged into papillae similar to the coronary corium and thus gives rise to tubular and inter-tubular horn. Frog corium is on the underside of the digital cushion and also is formed into papillae. The horn of the frog tends to be softer than that of the sole.

From this it can be seen that two hard structures, the horny hoof capsule and the pedal bone are held together by a soft layer, the interlocking dermal and epidermal laminae. This is the only means of support for the pedal bone within the hoof; the sole and lateral cartilages play no part in keeping the pedal bone suspended within the hoof. This arrangement obviously works well most of the time, until something goes wrong with the soft layer in the middle of the sandwich!

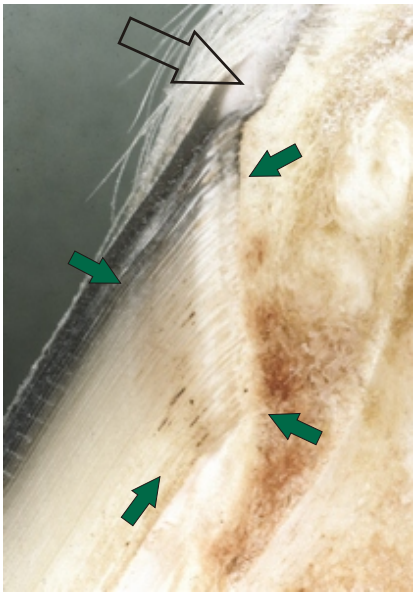

Figure 7. This figure shows the tissue around the coronary groove in the midline of the foot. A normal foot has been split down the midline, you are looking at the cut surface. Note the coronary papillae in longitudinal section (between the green arrowheads). Their direction, pointing down to the ground at the toe and parallel to the front surface of the pedal bone, is normal. The softer perioplic horn (open arrow) is produced above the horn from the coronary corium and covers the latter for about the top inch of the wall.

The blood supply

The blood supply to the foot is via the paired digital arteries, one on either side of the leg. These run down the back of the leg between the suspensory ligament and the deep digital flexor tendon and emerge around the back and sides of the fetlock joint; this is the easiest place to feel for their pulsation (Fig. 9.). From there they run down the back of the pastern, giving off branches to the coronary corium all the way round the foot, and a smallish area of laminae at the back of the foot around the heels (Fig. 10) .

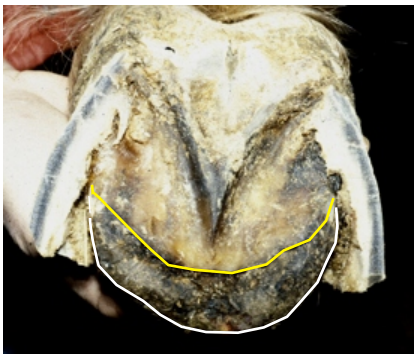

Figure 8. The sole and frog have been shed (and most of the hoof wall removed) from this pony which suffered an attack of acute founder. The figure shows how the sole and frog coria merge together, and as in this case new frog and sole horn has been produced to protect the sensitive tissues. The semi-circular outlines of the front of the pedal bone (white) and of the digital cushion (yellow) are as indicated. This pony made a full recovery.

Figure 9. Where to feel for the pulsation of the digital arteries as they pass over the proximal sesamoids, an increase in the 'strength' of the pulsation indicates either an inflammatory condition in the foot or laminitis.

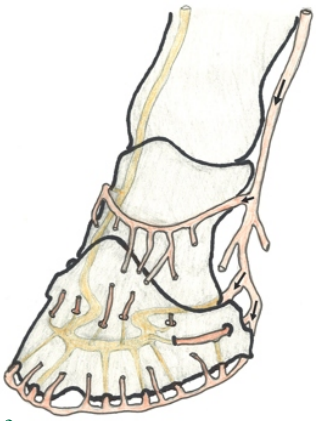

Figure 10. This diagram shows the essential features of the arterial blood supply to the foot. There are direct branches to the heels and the coronary band. The direction of blood flow is shown by the arrows.

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The digital arteries then pass down inside the collateral cartilages, which sit on top of the 'wings' of the pedal bone, and enter two holes on the undersurface of the pedal bone very close to the attachment of the deep digital flexor tendon. Once inside the bone they join up forming a semicircular artery known as the terminal arch. This terminal arch gives off about nine branches which go through the pedal bone and exit around the bottom rim to form another semi-circular artery, the circumflex artery of the pedal bone. This circumflex artery is outside the pedal bone and sits in a narrow space between the bottom rim of the pedal bone and the inside of the horny sole. In addition, the terminal arch gives off a few smaller branches which exit on the front surface of the pedal bone about half way up. The digital arteries, run underneath the horn on either side of the frog; the collateral frog sulci. These are the deep channels which start at the heels and join up around the point of frog. One normally picks out a foot by first clearing the collateral frog sulci with a hoof pick.

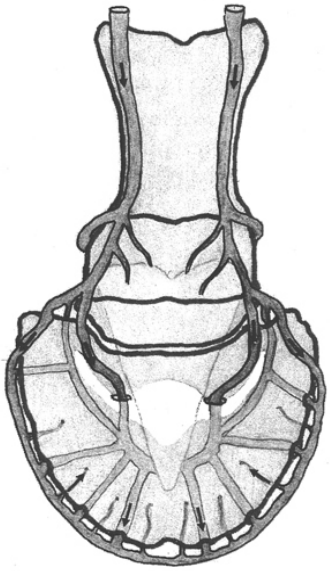

Figure 11. Diagram of the arterial supply to the foot as seen from underneath; the direction of blood flow is shown by the arrows. The large triangle represents the limits of the frog; if pressure is applied by means of a shoe which extends over the collateral frog sulci severe damage can be done to the arteries beneath. The white central area (shaped like the poll and horns of a bull) shows the position of the attachment of the deep digital flexor tendon to the underside of the pedal bone.

This anatomical arrangement is important because;
1 The arterial blood supply to the front part of the laminar corium is solely from branches arising from the terminal arch and circumflex artery. The arterial supply to this front part of the foot plus venous and lymphatic drainage are all in an upwards direction, against gravity.
2 There is no direct arterial supply to the solar corium from the terminal arch, it all arises from inward flow from the circumflex artery.
3 There are no major arterial branches directly under the frog.

Normal anatomy

From a diagram of a normal foot split down the midline, several important relationships can be seen (Figs. 12 & 13) . The phalanges [long pastern (proximal phalanx), short pastern, (middle phalanx), and pedal bone (distal phalanx)] are all in a straight line. The front surface of the pedal bone is parallel to the front of the hoof wall. The coronary corium is oval in cross-section and sits in the coronary groove at the top of the hoof. The coronary papillae are all aligned parallel to the front surface of the pedal bone. The top of the extensor process of the pedal bone is usually slightly below the top of the hoof wall. Rarely, the top of the extensor process is above the top of the hoof wall; this is normal for some animals. The horny sole is concave. The point of the frog extends in front of the insertion of the deep digital flexor tendon.

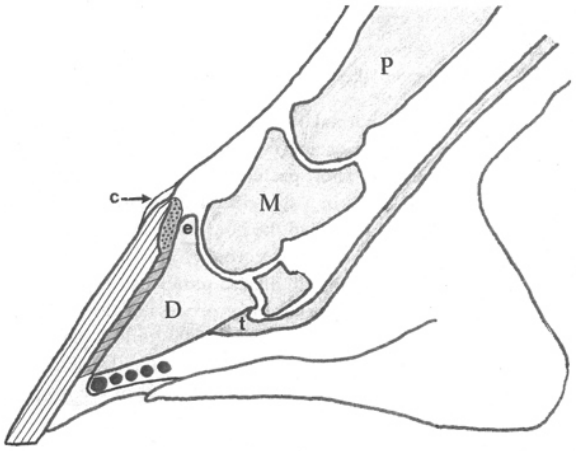

Figure 12. A normal front foot split down the centre and viewed from the cut surface.

Figure 13. Diagrammatic representation of the normal split foot shown in Figure 12. Stippled area = coronary corium; hatching = laminar corium. The three phalangeal bones (P, M, & D) are in a straight line. The top of the pedal bone (e for extensor process) is slightly below the coronary band (c). The coronary corium is oval in shape, the front of the hoof wall is parallel to the front of the pedal bone. The solid dots represent the circumflex artery of the pedal bone (at the front) and blood vessels within the solar corium. Note that the frog extends in front of the area of attachment of the deep digital flexor tendon (t).