The Missing Link
Architecture of the Foals Trim
And
Consequences of Orthopaedic Balance

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Introduction

Horse owners are often concerned as to when their foal/s have their first hoof trim.

This is a question that raises considerable debate in the professional and nonprofessional arena. Suggestions from some professionals (veterinarians, farriers, the racing industry etc.) are that foals don't need hoof care until they reach the age of one year or when they start training for their riding career. This could mean that the foal's hoof care program would be non-existent for a time frame of anything from birth up to the time they reach two or three years of age. This is unacceptable if we consider that proper hoof care is an animal welfare issue and not unfortunately just a financial concern as in the majority of cases. The equine industry should be placing much more importance on ensuring that shortly after birth the foal is given the best chance of ensuring quality of life and longevity by initiation of a regular trimming and chiropractic program.

When considering the question of when to do a foal's first trim it has to be taken into account the many different factors that can influence the structural integrity of the muscular-skeletal system of the foal and the ability of the animal to optimise its own functional systems to stimulate and ensure long term soundness.

Some foals are born with structural issues such as major or minor leg or hoof deviations and upper torso compensation patterns. In severe cases foals may require early intervention by a veterinarian which may require surgery. These structural issues may be a symptom of what has taken place in utero or as difficulties during or shortly after birth. It is critical that shortly after birth the foal is checked and in the days following monitored for any deviations in the developing structures. It is also crucial that any intervention procedures are adequate and optimal for the ongoing needs of the foal to ensure long term structural integrity and thus performance of the mature horse.

The author believes that understanding the importance of biomechanical medicine and the orthopaedic balance of the newborn foal is critical to this process. The key to foal structural soundness is early diagnosis and correct structural intervention to minimise these types of deviations and dysfunctional systems in the foal. It is of concern that proper consideration is not given to the importance of early and routine hoof care and the consequences it will have on the orthopaedic stance of the foal. The acknowledgement of the forces being placed on the early development of the muscular-skeletal and neuromuscular systems enables hoof trimming, orthopaedic balance & chiropractic techniques to correctly adjust a foal early in life. These early adjustments can improve minor deviation (even effect foals born with straight legs) of the foal's legs and will have a profound influence on the development stage of the neurological and structural systems of the animal.

The newborn foal

Newborn foals have soft hooves and are usually presented more pointed at the toe with under-run heels. This enables ease of passage for the foal through the birth canal. It also lessens internal damage to the mare and damage to the placenta upon delivery. This is called the foal foot. At approximately 3 months of age (in domesticated animals) this foal foot has grown out and is replaced with the normal adult hoof.


The new born foal

As the foal begins to move around the foot starts to take a more normal shape due to weight bearing and the wear and tear of the environment they experience. In non-domesticated animals the natural environment would ensure that the developing hoof capsule is worn in correlation to the terrain and the structural needs of the animal. This ensures that the self-correcting of the weight bearing surface of the hoof is as close to correct as possible and the strain on the developing hoof and upper torso is greatly reduced.

Foals born in the wild have the freedom of movement to be able to strengthen their muscles which enables them to stand correctly. Foals tend to stand for the first few days with their legs bent in at the knee and hock as they try to gain their strength and balance. This places stress on the carpal bones (knees) and tarsal bones (hocks) and changes the orthopaedic balance of the foal even at this early stage. This will then have an effect on the upper body and will influence the growth plates of the skeletal system and growth of the hoof capsule.

As a foal grows & moves it starts to straighten its limbs, however due to the bulk of the upper body (especially in heavy foals) and the early instability of its stance the foal tends to lay over at the knee and hock, which will change the orthopaedic balance and upper body alignment. Some foals have large upper bodies as well as small feet and this can cause problems due to the amount of weight being placed on these small weigh bearing structures. Foals with this issue need to be checked on a regular basis for correct orthopaedic alignment as this is when the growth plates require their alignment assured. It is important to note that foals need to have a lot of movement to enable their feet as well as their muscular-skeletal and neuromuscular systems to strengthen correctly.

Most of the common problems foals have in the first few months will be in their legs as many are born with some deviation which will increase in time without treatment. They are either over or behind the alignment of the knee or the leg turns in or out causing the foal to change their orthopaedic stance and upper body alignment. If this is allowed to continue, then the growth plates in the limbs of the foal will be set in this manner. This will then change the conformation of the animal for life. However, if the structural changes are assessed and corrected at an early stage then the foal can place its weight correctly through the bony column of the limb, and the growth plates can be (in most cases) set in correct alignment with the upper body.

This is the case for early intervention which should maximise the success and integrity of the structures involved and thus the future development of a sound horse.

Checking the orthopaedic balance of the foal

To check the conformation of the foal the practitioner should examine the overall appearance of the foal from a distance of approx. 10 feet. This allows the entire foal to be seen which enables easier identification of common faults.

Pick up the foals' front limbs singly behind the knee and let the limb hang free (this will take out the muscle influence on the limb). Check to see if the radius (forearm) and the third metacarpal bone (cannon bone) are in a straight line and the phalanx bones (pastern bones) line up with it. This is a true test of bone alignment (conformation) without incorrect muscular tension having an influence on the limb structure.

The back limbs are viewed by holding the limb behind the hock and letting the limb hang free. Look straight down the limb alignment. Again, the tibia bone (gaskin) and third metatarsal bone (cannon bone) should be in a straight line and the phalanx bones (pastern bones) should be in line with them.

The author's long term clinical observations show that the hoof grows faster on the side of least pressure. If the limb is lying in at the knee or hock, then the hoof capsule will tend to grow faster on the lateral side (outside) and this will cause the limb to keep turning in. If the knee or hock is lying outwards, then the pressure will cause the hoof capsule to grow faster on the medial side (inside) and this will turn the limb out. It is at this stage that the hoof needs to be trimmed to control the changing pressure in the hoof capsule.

The author recommends assessing foals at birth where possible and if not then within 48 hours of birth. Should the practitioner's assessment determine that treatment is required (chiropractic or orthopaedic trimming), this is the window of opportunity to ensure optimal integrity of the foal's structural and neurological systems.

The author recommends beginning foal hoof trims on a regular basis from 4 to 5 weeks of age. At a minimum, regular trims should begin no later than about 2 ½ months, just before the foal foot has grown out and is replaced by the mature hoof capsule.

The guidelines for foal trims should always be to use the external pathology of the foot to guide the procedure and to identify any dysfunctional pathology of the distal limb and trim accordingly. This allows control of the hoof capsule alignment through regular trimming and ensures the correct orthopaedic balance of the foal.

The hoof needs to be balanced to ensure the foot strikes the ground equally. If this does not happen, then the foot will twist towards the longer side while on the ground and will wing towards the opposite direction during flight. This is the action of the leg (due to muscle tension) untwisting itself. Hoof balance plays a substantial part in the movement of the limbs and alignment of the bodies skeletal and muscle attachment.

Incorrect hoof balance in the early stages of a foal's life can change the orthopaedic stance of the animal along with the biomechanics of the hoof. Incorrect hoof balance can cause a foot to toe in or out and this in return changes the forces placed on the skeletal structure causing it to rotate out of alignment. For example, if the medial side of the front hoof is low then this can cause the radius and ulna bones to rotate inwards and place extra pressure on the ribs and sternum area. This will then be detected in the neuromuscular system of the foal and causes an individual compensation pattern affecting the loins and then the forward movement of the hind quarters. These compensation patterns can also place stresses on the humerus and scapula and the muscle attachment in that area and cause loss of forward movement of the front limbs. Due to the fore limbs only being held in place by the muscular system and not connecting to the main skeleton with a socket joint as in the hind limbs, it is paramount that the limb structure is maintained in correct alignment with the body. Any misalignment of the fore limbs will cause a compensation pattern in the muscular system (passive stay muscles), neurological system (neural circuitry responsible for synchronisation of the limbs) and this will impact on movement and weight-bearing when in motion as well as the stance stage when at rest.

This movement and standing compensation pattern is again repeated in the hind limb if the hoof balance is not correct. The extra force placed on the top of the tibia and base of the femur can rotate the pelvis and place pressure on the vertebral column causing pain and the unwillingness of the animal to move freely forward.

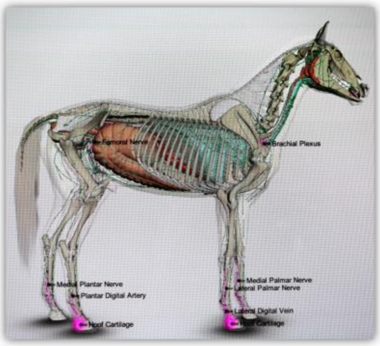


Photo by 3D Horse Anatomy

When hoof balance is incorrect it correspondingly places extra pressure on the biomechanics of the hoof causing pain and furthermore the stance of the horse is changed. Foals that have hoof pain in the front feet tend to carry their head and neck in a higher position, contributing to a considerable part in the rebalancing of the animal. This is organised through a network of nerve fibres branching out of the spinal cord at C5, C6, C7 and T1 and are known as the Brachial Plexus. It supplies the neck and fore limbs with information to the appropriate part of the limb. If we take into account the segmental motion of the equines neck (flexion, extension and articulation) this could be why we see foals with lateral limb movement problems presenting with lateral movement issues at C6 and C7 and holding at C1 and C2 as the animal counteracts the dysfunctional body. It is this rebalancing act of a high neck carriage that shortens the extension (holding the weight off the foot) of the limb structure downwards into the hoof and preventing proper hoof function. This individual (animal/limb) rebalancing / compensating pattern is what compromises the orthopaedic stance of the animal through the neuro-muscular response causing changes neurologically in all systems of the animal. These changes in the neuro-muscular response means we are getting alterations of the neural fibres in this area, changing the signals to the muscles involved and the consequences are dysfunctional muscles and altered locomotion of the limbs involved or of the entire animal. This altered locomotion affects the vascular and neurological systems to the hoof and without the correct hoof expansion can cause problems like contracted or underrun heels as the foal matures. This places extra pressure on the internal structures of the hoof (distal phalanx, distal sesamoid bone, deep flexor tendon, digital cushion etc.) all causing pain and ultimately stress in the upper body and impedes the correct muscular development of the growing foal.

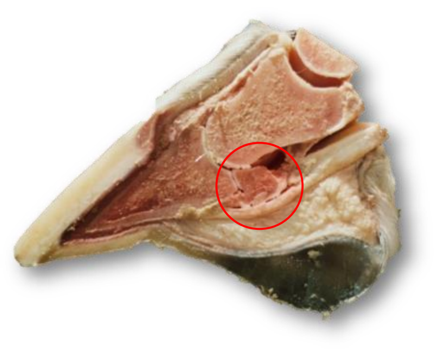
This orthopaedic imbalance is achieved through the complex design of the foot and involves the vascular and neurological systems of the horse. As the foot is divided into many different sections each of these has its own unique role to play in dissipating the forces of impact with the ground and the orthopaedic loading of the limb.

Looking at the loading of the distal limb, the main loading is placed through the palmar section of the foot and some of the main structures involved include the hoof capsule, digital cushion, collateral ligaments of the distal interphalangeal joint, distal cartilages, deep flexor tendon, impar ligament, distal sesamoidean collateral ligaments along with the bones of the distal interphalangeal joint being distal phalanx, middle phalanx, navicular bone.

Photo from The Illustrated Horse's Foot by Christopher Pollitt

As the distal bones that make up the distal interphalangeal joint carry most of the loading of the limb, its articulation is extremely important to the functional integrity of the foot to ensure longevity and soundness in the future. The palmar aspect of the solar (underside) surface of the distal phalanx forms the attachment site of the deep digital flexor tendon and the impar ligament of the distal sesamoidean bone (navicular bone). This allows for the structural alignment of deep flexor tendon with navicular bone and therefore the articulation within the joint, this will then cause a neuro-muscular tension response in the corresponding passive stay apparatus. The navicular bursa also sits between the deep digital flexor tendon and the navicular bone allowing for smooth articulation of the deep digital flexor tendon over the joint. The deep digital flexor tendon sheath encapsulates the tendon down the distal limb and terminates approximately at the level of the centre of middle phalanx and it is also prone to damage caused by incorrect orthopaedic loading and long-term misalignment of the interphalangeal joint.

The distal phalanx bone has two palmar processors commonly called the wings of P3 which extend palmarly (backwards) and abaxially (to both sides away from the centre) from the bone and form one of the attachment structures for the distal cartilages (external pathology point for EOB). Within these wings of the distal phalanx lays the navicular bone. The navicular bone is a butterfly shape bone and has two surfaces that articulate within the interphalangeal joint, that being the distal palmar aspect of the middle phalanx and the palmar aspect of the distal phalanx. The articular surface of the middle phalanx is the main articulation point and the smaller and secondary articulation point being the distal phalanx for the navicular bone. The navicular bone also has two surfaces containing ligaments that form part of the supporting structure which are the proximal surface for the connection of the collateral sesamoidean ligament and the distal surface for the attachment of impar ligament. It is imperative to the integrity of the palmar section of the foot that the articulation of navicular bone is correct within this interphalangeal joint and the correct alignment of the deep digital flexor tendon (this is the reasoning to include the external alignment of DDFT as part of EOB's pathology assessment).



This distal interphalangeal joints structural integrity is also reliant on the distal collateral cartilages as they attach to the palmar process on either side of the distal phalanx and the distal aspect of middle phalanx. Medially adjacent to the central-palmar aspect of the distal cartilages lies the palmar digital artery and palmar digital vein along with the palmar digital nerve. You will find that the cartilage structure position is approximately one-half within the boundary of the hoof capsule and the remainder is proximal (above) to the hoof capsule. The distal interphalangeal joint does have several other ligaments that attach the collateral cartilages to the joint and all three phalangeal bones (again the reasoning to include the external alignment of the distal cartilages and proximal attachment point as part of EOB's pathology assessment).

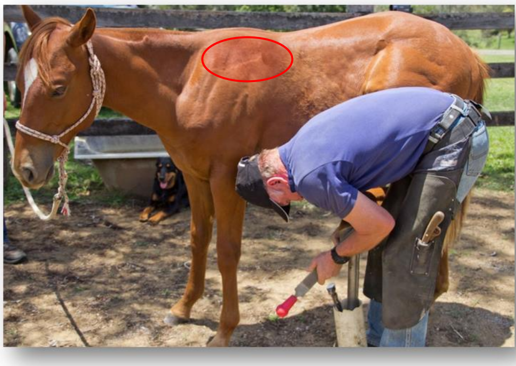
When looking at the function of the navicular bone, we find it has very little movement, so the distal phalanx and the navicular bone essentially function as a single articulating unit articulating with the head of middle phalanx. This allows for the corresponding surfaces of the middle phalanx to be consistent or matching with the articulating surfaces of distal phalanx and navicular bone. The joint configuration allows for it to bend upwards and have considerable rotation along with some slight medio-lateral flexion with the distal phalanx, which is what allows the foot to accommodate for the irregularities in the ground underfoot. As the deep flexor tendon descends over the palmar section of the interphalangeal joint it passes close to the external surface of the pastern and gives the practitioner a point of reference for checking its structural integrity and an indication of pain response.

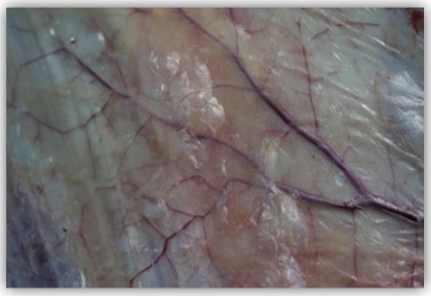
The interphalangeal joint articulation is very complex because it has three surfaces in articulation at once. The practitioner has to ensure the structural integrity of all the soft tissue in the palmar section of the foot supporting or encompassing this joint, so it can remain at its optimal function. When treating hoof ailments of any kind it is a very important point to remember that if the horse cannot place its weight/pressure on the correct weight bearing surface (internal- P3 or external- hoof capsule) then the compensation patterns of incorrect orthopaedic balance are experienced throughout the entire horse. In cases of hoof imbalance, the nervous system of the horse has to adapt to allow compensation in all soft tissues. This is why we have fasciae changes, muscular tension and ligament imbalances.

Traditional trimming techniques attempt to correct the alignment of the growing hoof by addressing the balance of the external weight bearing surface with little consideration for the internal orthopaedic loading of the distal interphalangeal joint and the proceeding neuromuscular responses. The goals of most traditional techniques are to keep the movement of the limb straight and encourage the hoof to conform to the predetermined measurements and angles deemed to be normal. This is usually done by squaring off the toe area of the hoof capsule (and in some cases raising of the palmar section to release tension on the deep digital flexor tendon) and trimming to correct the wear patterns due to the pointed shape of the new foal's foot. The aim is to provide a straight and shortened break-over point on the hoof in the belief that this will discourage deviation in the limb and normalise the stride and movement path of the limb. The problem with this traditional trimming technique is that it does not contribute to the correct orthopaedic balance of the distal limb or to the complex articulation of interphalangeal joint and the encompassing soft tissue supporting this structure. The authors clinical findings are that neglecting the external pathology changes taking place in the hoof and trimming to the mathematical equations of size and angles will only cause additional trauma to the internal weight bearing structures of the hoof (distal phalanx, distal sesamoid bone, deep flexor tendon) all causing pain and ultimately stress in the upper torso and impeding the correct muscular development of the growing foal.

Principles of connective tissue

When understanding the orthopaedic balance of the foal we must consider the fascia as it is the principal connective tissue in the equine body. It forms a continuous three-dimensional web that surrounds and supports all muscles and organs of the body and holds them in their individual place. There are two main sub-classifications of connective tissue.





They are the connective tissue itself (referred to as proper) and the specialized connective tissue. Connective tissue proper is subdivided further into loose (as areolar) and dense. Loose is distributed everywhere throughout the body filling in areas between blood vessels and the substance of organs through which vessels course and beneath the covering of the skin and lining of the structure. Dense connective tissue makes up the structure of deep fascia, aponeuroses, tendons, ligaments, and the capsules of many organs. Specialized connective tissue is further subdivided into adipose, cartilage, bone, and blood. The fascia is classified according to their arranged layers, from superficial to deep and is separated by loose connective tissue to allow other fascia to smoothly slide over each other. The layers are functionally continuous with the other main connective tissues, those being muscles, tendons, ligaments, the periosteum and bones. Each layer of fascia contains closely packed varying proportions of collagen and elastin fibres. Human research is now showing some fascia also contains small amounts of smooth muscle indicating that it has an active contractile function as well as a passive mechanical role. The fascia layers reach down deep into the muscles and organs carrying many varied nerves and vessels which facilitate metabolic as well as physical support. The loose connective tissue also acts as a reservoir of metabolites and can act as a store for the by-product of illness or stress. It is highly innervated and clearly has a strong proprioceptive role.

The fascia is similar to any other tissue in the body, it is susceptible to injury and disease and at the superficial layer it takes all the everyday knocks and bumps. This causes damaged tissue to stimulate fibroblastic proliferation as part of the repair process, which can lead to fibrosis / scar tissue. It is important to consider the constant orthopaedic loading of the limbs and upper body of the foal because if the orthopaedic balance of the animal is incorrect the micro trauma will cause the foal to change its stance even more and that will invariably lead to fibrosis within the fascia itself and facial adhesions between the tissues planes. Stecco et al in a histological study of the deep fascia of the limbs concluded that the ability of the collagen layers to slide over one another could be altered by overuse, trauma or surgery. Fibrosis causes constriction around nerves and vessels, causing pain along with proprioceptive and metabolic disturbances, in addition to altering the function of the tissue itself. It has been found that by releasing the tension on the fascia and returning it to its normal function can release pressure on the pain sensitive structures such as blood vessels and nerves found throughout the body.

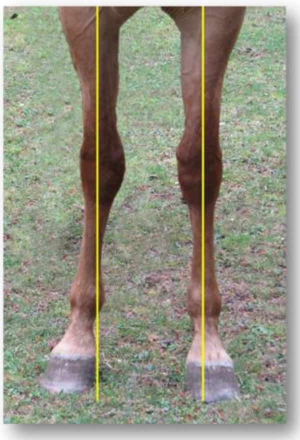
The stress of tendon, ligaments and connective tissu**e**

Injury or orthopaedic imbalance in the body usually results in some form of restriction in the facial tissue that encompasses the entire body. This challenged fascial tissue will then tend to form scare tissue that can produce restrictions at the local site of injury or anywhere else in the horses' body.

These myofascial changes in the body of the foal can be detected at myofascial trigger points (sensitive spots in muscles) and they might be visible in the form of a fascia line around the top of the scapular or at the last ribs of the foal. This strain or imbalance (site of stress) creates a protective reaction in the muscles and is transferred to the tendons and ligaments and their attachments (entheses – where tendons and ligaments meet the bone) to the skeletal components of the animal. This will change the mobility and flexibility of the skeletal system. This then decreases the foal's ability to make adjustments standing or moving when needed. Many things can cause dysfunction in the tendons and ligaments throughout the foal; however many dysfunctions are a consequence of incorrect neural transmission due to stress, injured areas or incorrect orthopaedic balance. These incorrect neural signals are the neuro-muscular response to the imbalance of the animal and the stress of the myofascial tissue being restricted or losing its mobility. This myofascial restriction leads to associated stress in the muscular system through incorrect tendon and ligamentous tension, and in chronic cases the neurological system can become over reactive and highly sensitive causing progressive damage to itself and the muscular system.

In foals the author has observed this on a daily base. When the connective tissue loses its fibre connections and thus strength, the muscular system becomes unstable (seen in foals that cannot lock their joints or maintain correct or prolonged stance). Damaged tissue (muscular or hoof related) is the result. When the connective tissue system is compromised the neurological system is always challenged. This causes type IV mechanoreceptors (called nociceptors or pain receptors) to be stimulated which impedes normal signal transfer through the nervous system to the muscular system. The consequences of this are incorrect movement and orthopaedic balance throughout the foal. This damage is commonly found in the upper half of the torso of the foal at the origin site of the ligaments and tendons, and continuation of damage or stress to these areas will result in compromised nerve (neurotransmission) and blood supply (vascular infusion) to the muscular-skeletal and connective tissue systems.

As practitioners you are often instructed to palpate the muscles of the equine to ascertain the soreness and the mobility of the tissue involved. However, the author believes that not enough thought is given to the involvement of the attachments of the muscular system to the skeletal system and the effect it has on the orthopaedic balance of the animal. These points of attachment (especially the origin – top attachment) are the areas that carry most of the stress with the flexion and extension (the distal section involved moves the dorsal origin on extension) of the muscles involved. When the load on the muscular system is increased, the forces are transferred to the tendon and ligament attachments involved. These forces acting on the attachment will cause either correct or incorrect alignment of the skeletal system (posture / stance) and therefore be transferred to the individual joints.



A foal which develops without having early routine hoof care or being correctly assessed in the first two to three months' post birth can present as a maturing or adult horse with evident orthopaedic balance consequences. Symptoms of stress we commonly observe (mostly after the first year of age) in the muscular system and dependant on the amount of trauma are unevenness, tightness, tenderness, loss of muscle, marbling and roughness of the tissue, small holes in the tissue, points of pain over different areas and signs of misaligned or thickening of the connective tissue on the outer surface of the body. One of the big issues in formulating a diagnosis is that when palpating the muscular system looking for signs of pain the response does not always give a true indication of the stress or trauma to that area. This is mostly due to the individual animal's neuromuscular response and the ability of the animal to deal with pain or discomfort. This could mean that some animals exhibit no active signs of pain with major trauma (e.g., muscle tears) or long term chronic issues and will only present with minimal pain or tenderness on palpation. It then becomes imperative for the practitioner to use all diagnostic parameters (not necessarily at the site of pain) to comprehend the full amount of change to the mobility and stability of the different systems involved.

When working on the orthopaedic balance of the equine the practitioner should consider the referred pain patterns of the individual animal being diagnosed. These referred pain patterns are signs of compensation patterns which are unique to that animal. When understood these can help establish the systems the horse is using to offset the trauma or incorrect orthopaedic balance. An equine that presents with distal limb or hoof issues will in most cases try to offload the forces being transferred to the site of stress or injury and correspond by transferring the weight to the opposite limb or other compensation patterns throughout the body. This is commonly observed when a horse has a problem in one of the fore limbs as it usually transfers the weight to the opposite limb first. This is achieved by changing the head or neck carriage by holding the neck higher causing a change in the posture or stance of the animal. This change in stance will cause the shoulders of the animal to become misaligned with each other. The consequences of this cause a compensation pattern of lowering the back and rising or straitening of the pelvis (hip angle). It is these compensation patterns that are unique to the individual equine and through the neuromuscular responses will produce restrictions at the local site of injury or other distant sites such as the Temporal-Mandibular Joint (TMJ). It is all part of the rebalancing act of correcting its own orthopaedic balance.

It is the ability of the practitioner to isolate the neuromuscular responses causing the restrictive changes in the fascial tissue which encompass the entire body. It is these responses which create a protective reaction in the muscles which are transferred to the tendons, ligaments and their attachments to the skeletal components. This then changes the mobility and flexibility of the skeletal system to be able to make adjustments to the movement of the limbs along with the resting stance of the animal.

Understanding the complex orthopaedic balance of the foal is a safe, reliable and scientifically credible key to formulating a treatment strategy for ailments that change the orthopaedic balance and impair the quality of life for the foals in your care.

Consequences of orthopaedic balance

To understand the complex interrelationships of hoof balance and the overall biomechanics requires careful scrutiny of external hoof pathology as well as an understanding of what is transpiring in the internal structures of the hoof. Recognising and placing

Photo from The Illustrated Horse's Foot by Chris Pollitt emphasis on external macro-pathology may be somewhat of a 'missing link' which is vital to gain a satisfactory outcome. Once this is achieved it is then necessary to consider the changes in the upper body of the equine. These changes can be dynamic reloading patterns resulting in muscle tension patterns, fatigue of the major muscles of the passive stay apparatus, eventual chronic alteration of ligament tension and persisting pain issues. It is worth exploring this inter-relationship by considering misalignment of tissue structures more commonly encountered with problems in the forelimb.

When the internal hoof structures (and the individual tissue) are placed under stress, the functional biomechanics and muscular–skeletal alignment of the upper body is affected, thus all aspects of limb and hoof movement will change. Recognition of these influences in the upper body of the animal is required for the method of hoof trimming and shoeing. This rebalancing of the hoof by the practitioner is the single most influential thing that would induce modifications to the biomechanics of the foot and the animal's upper body.

The other important influence is a comprehensive chiropractic treatment. This is to ensure that the horse's weight and kinetic energy is transferred directly through the limbs to the bone structure of the hooves. Orthopaedically the hoof capsule has to encapsulate the bones symmetrically otherwise weight and energy cannot be transferred to the ground correctly. Incorrect weight transfer causes the horse to change its movement pattern as well as its upper body muscular system. Long term problems result as hoof and/or upper body problems which reduce the performance of the horse.

Orthopaedic Balance of the Equine

To understand complex structural and functional podiatry problems a practitioner needs to identify the external pathology of the foot by observing the texture, size, colour, shape and alignment of each section of the hoof to ensure it is coping with the stress placed upon it. Knowing how and why a problem has occurred and understanding the response of the horse to it is one of the keys to the knowledge of a broad range of equine problems.

Clues as to how the equine copes with hoof related issues are found throughout the entire body. Only a careful examination from a structural and functional perspective will reveal variations in muscle tension, ligament tension and hoof pathology. Subtle variations in movement patterns develop as the horse tries to avoid pain with the ramifications of dysfunction or imbalance. If pain increases there can be dramatic alterations in the horse's behaviour as well as performance. There can also be alterations in the loading of individual limbs from one side to the other, from the front limbs to the hind limbs or a diagonal loading imbalance, all being possible consequences. With this loading imbalance, the work certain muscle groups do increases or decreases and can cause muscle fatigue throughout the muscular system.

The practitioner needs to take into consideration the role of muscle and ligament mechanoreceptors in the movement of the horse as well as the external and more importantly the micro pathology of the hoof to fully understand the afflicting issues.

The Diagnostic Process

Step 1: The whole horse

- Observing the animal from a distance of at least 10-15 feet will allows the practitioner a complete overview of the upper body of the horse, as hoof or imbalance complications manifest themselves as changes or misalignments in the upper torso of the animal.

- The practitioner should investigate things like, asymmetrical muscle shapes, atrophy of the Longissimus muscle behind the scapula, no top line, a dip at the lumber or croup area or an awkward stance of the animal. Individually or all of these factors could mean that the animal has modified its orthopaedic stance.
- Working your way through the diagnostic process, palpate down the limbs feeling for swelling, asymmetrical tendons or ligaments, knots in suspensory apparatus or swelling at the base of the proximal phalanx where the collateral ligaments of distal sesamoid attach.
- These specific signs will start to indicate if the orthopaedic stance of the horse is compromised, as this influences the functional loading of the distal interphalangeal joint (DIPJ).

Step 2: Diagnosing hoof balance by tendon alignment.
Utilising the distal tendons and ligaments the practitioner will discover a consistent way of assessing the imbalance or balance present in the animal's foot, as this is the horse indicating the individual loading of that particular foot or limb. The Deep Digital Flexor Tendon (DDFT) to indicate the loading on the distal sesamoid bone. By examining the DDFT the practitioner can acquire an enormous understanding of the effect of the medial-lateral loading the animal is placing on the individual distal limb. Along with assessing the alignment of the distal cartilages the practitioner can have the advantage in comprehending the loading forces situated on distal phalanx and the assessing the anterior-posterior axis of the DIPJ.

- Begin with a front foot. Slide your hand down the length of the third metacarpal palpating the DDFT and Superficial Digital Flexor Tendon (SDFT) to assess the alignment of the individual tendons with the third metacarpal bone.
- Correspondingly palpate the sub carpal check ligament at the same time. The appropriate loading of the limb will ensure that the DDFT and SDFT are in alignment with each other and align in the centre of the third metacarpal bone; the sub carpal check ligament ought to be under little stain. An indication that the DDFT tends to run out to one side of the SDFT is indicating that the distal sesamoid bone is out of alignment with P3. When SDFT tends to rotate to one side of the third metacarpal bone more than the other, this is an indication that the imbalance is coming more from the proximal lower distal limb joints. The advantages of incorporating the distal cartilages in the diagnosis, is an indication of the loading situated on each individual or both abaxial wings of P3, distal sesamoidean bone and the distal joint of P2 and P3.

- As a testing point for tension of the sesamoidean bone the practitioner can apply slight pressure to the distal point of DDFT in the hoof as it descends between the distal cartilages (DC). By palpating this area between the DC, the process will reveal any inappropriate existing tension and the animal will indicate by pulling away of the limb.

- Assessing the soreness in the DDFT is best carried out by holding the leg at the fetlock so the frog is perpendicular to the ground and by applying slight pressure to the DDFT at the incursion point of sub carpal check ligament will indicate any existing soreness. Having an appreciation of the tendon alignment before the trimming process allows the practitioner a new assessment method of the imbalance that could be present in the weight bearing surface of the hoof. Palpating the position of DDFT will indicate the side of the hoof that needs to be lowered to relieve tension. The SDFT and the DDFT should lay directly over each other and directly in the centre of the cannon bone, with the DDFT neither pushing out on one side nor being pulled in under the SDFT.

- Commence feeling 1/3 below the carpal joint at the insertion of check ligament. Identify both tendons and place you thumb and index finger medially and laterally on the tendons, the individual tendons should be easy to distinguish. Then run your fingers down the tendons all the way to the fetlock joint. In case of a lateral high side of the hoof capsule the DDFT will start to disappear on the medial side under the SDFT just below the check ligament. It will become more obvious the further you feel distally towards the fetlock joint. In acute cases of imbalance, the DDFT can be felt bulging out on the lateral side as well as disappearing on the medial aspect. With a standard lateral-medial (lateral high) imbalance the medial distal cartilage will also be raised and hard on palpation. On completion of the trimming process (results will be subject to individual cases) the descending tendons and distal cartilage tension will be more neutralised and the tendon alignment will return closer to normal.

Step 3: The hoof balance

- When assessing the front foot for appropriate balance (medial-lateral) the practitioner should hold the foot at the fetlock joint and allow the foot to adopt a natural position. Positioning themselves as close to the shoulder (and facing the hind limb) of the animal as possible (pulling the limb out from the body will twist the limb and reveal an incorrect hoof balance). This position will allow for an optimal viewing of the hoof-bearing surface to gauge the correct balance.
- The position for assessing the appropriate balance of the hind foot is for the practitioner to cradle the limb in their lap (with their back to the horse), with the fetlock joint of the animal resting on their knees as this will allow the foot to adopt a natural position.
- Again the practitioner should position themselves as close to the body as possible and sighting straight down metatarsal 3 they can assess the appropriate hoof-bearing surface of the foot.

- When assessing the limb alignment of the front legs the muscular tension could cause the limb to be misaligned with the torso of the animal. This continual muscular tension can produce a rotation effect of the limb causing the front limb to sometimes hang inside or outside the alignment of the hind limb. The correct alignment of the front limb is to align with the hind limb. When presented with a fore limb misalignment to the medial aspect the practitioner should place their knee against the horse's knee and rotate the limb to face in line with the hind limb. If the limb alignment is to the lateral aspect the practitioner should place their hand on the medial aspect of the horse's knee and rotate the limb to face in line with the hind limb. By aligning the foreleg to the body in this way a true indication of the appropriate hoof balance is given. It is also an effective way to determine if pressure is being placed on the muscular-skeletal system of the animal.

- With assessing the hind limb, it can be challenging to formulate correct alignment of the limb. However, if the tension on the limb is problematic the limb will become challenging to keep in an elevated position, this is usually an indication that the muscles of the hind quarters are being strained (tight hamstrings, croup and buttocks area).

Signs of a healthy hoof and a hoof under stress

Healthy hoof characteristics:

- Symmetrical in shape with a smooth even cone shaped exterior wall.
- The sole should be concave from the outer wall to the junction of the apex of the frog and sole.
- The white line should be opaque in colour with an even width around the circumference of the wall and finish two-thirds the way down the length of the frog.
- The sole of the hoof should connect to the white line at the same height as the hoof wall creating a healthy connection to the hoof capsule.
- The bars should be straight and in line with the frog.
- The frog should be a healthy wedge or triangle shape whose ground surface finishes just below (viewed from underneath) the level of the heels.

Any deviations from these characteristics are for a reason. The practitioner must then determine what is dysfunctional, why it is dysfunctional, and how to go about correcting it and returning the hoof back to a healthy state.

There are many signs of imbalance to look for in a hoof and not just the hoof and pastern axis analysis.

Stressed hoof characteristics:

- concave or convex hoof walls
- flares in the hoof wall
- misalignment of the coronet line (pushed up or waves)
- shelly hoof walls
- cracks in hoof walls (stress cracks)

- bleeding from coronet band
- heel bulbs extending out the back
- underrun heels
- distal cartilage alignment

The external signs seen when examining the hoof on the ground are only telling us half of the story. The practitioner must also observe pathological changes taking place in the hoof.

Signs of hoof misalignment:

- hoof shape
- texture (hoof, sole, frog, white line)
- pigmentation changes (white line, frog, sole)
- frog shape
- extra layering down of sole
- hoof capsule thickness and wear
- abnormal fusing of frog and sole
- bruising or bleeding through the sole or white line
- size of white line
- Sole alignment with the white line and wall.

All the above signs are a guide for the practitioner an in-depth analysis system as to the healthiness and correct alignment of the internal structure of the hoof.

Palmar section of the foot

The palmer section is the most important part of the hoof. It is very important to understand and recognise structural transformations that may be occurring. The palmer section is the main support system for the horse, thus is the key to optimal hoof function.

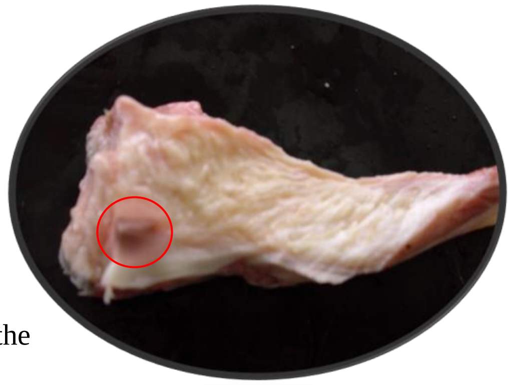
There are several parts that are integral to the dissipation of energy in the hoof. These are the digital cushion, internal bars and collateral cartilage. When operating in unison they reduce wear and tear on the hoof, legs and upper torso of the horse. When this relationship between soft tissue and the bony column structure of the limb becomes strained, the internal soft tissue of the foot commences to modify its texture and then its alignment.

The digital cushion plays one of the most important parts of supporting the leg and maintaining hoof and limb alignment. It also reduces excess movement and concussion on the distal limb and thus the upper body. However, if the digital cushion is not contained correctly by the internal bars of the hoof and held in place by the collateral cartilages, then its alignment within the hoof capsule will change and along with that its ability to function correctly.

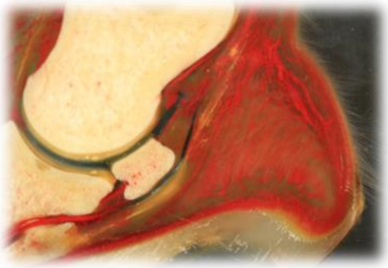
The internal bars of the foot are one of the first pieces in this chain that begins to breakdown. When this happens, it can no longer correctly contain the digital cushion, help support the bony column of the limb, or allow the hoof capsule to maintain a functioning internal relationship with the distal bones of the leg.

When the internal bars of the foot are incorrectly loaded, they quickly commence changing according to the loading forces they experience. They modify their alignment forward and new epidermal tissue protrudes laterally or bilaterally to the normal alignment. A healthy internal bar seen laterally is a triangle shape with the apex commencing at the apex of the frog and the base at the palmar section of the hoof. The inner bilateral walls of the bars that contain the digital cushion are straight and smooth with a slight concave co-laterally at the distal palmar area. The outer wall is slightly concave and thinner at the proximal boarder, and thicker and more developed at its distal boarder. These structural characteristics allow for precise alignment of the wings of distal phalanx and containing digital cushion to be under the principal structure of the leg.

The small inner bilateral concavity of the internal bar structure accommodates a small pyramid shaped amount of digital cushion. The author calls this the “Collateral Distal Branches of the Digital Cushion”. It is the area of the hoof which has first contact with the ground. It is this Collateral Distal Branches of the Digital Cushion that helps to support the internal bars, gives the area better impact absorbing ability and assists in the hoof expansion process.



The Collateral Distal Branches of the Digital Cushion are one of the earliest areas to come under stress and break down. It is paramount that the Collateral Distal Branches of the Digital Cushion are intact for hoof function and reduction in upper body stress. Inappropriate pressures along with reduced vascular flow to the internal bars trigger the tissue of the Collateral Distal Branches of the Digital to degenerate. The bars now start to reduce in height. The distal palmar section of the bars develops more fibro cartilaginous like material and becomes more prominent and encroaches on the wings of P3. The proximal palmar area of the bar now begins to roll under causing the entire internal bar to migrate dorsally towards the toe. These changes signify that the digital cushion is forced to carry more than its share of weight and this extra loading along with the compression alters the tissue alignment and vascular flow causing tissue breakdown. This is the commencement of the podiatry problems visible on the external hoof capsule such as underrun heels, medial –lateral flares, concaved dorsal walls, extruded bulbs of the heels etc.



The tissue of a healthy digital cushion promptly goes from appearing similar to what is often described as the head of a cauliflower. It is a tightly formed cellular collectively supporting the upper body weight of the animal and furthermore counteracting the forces of ground impact.

A dysfunctional digital cushion resembles individual layers of elongated tissue which are unable to maintain its overall wedge shape and also has minimal supporting ability. It then works as two separate individual components. The distal section which is below the heel bulb alignment begins to diminish in size and the proximal section stars to extend palmarly compelling the remodelling of the heel bulbs. With the digital cushion unable to maintain suitable alignment or support, the loading forces are transferred to the DDFT, navicular bone, bursa, impar ligament and collateral ligaments. This alters the internal relationship between the hoof capsule and distal bone structures of the limb and transforms the orthopaedic balance of the animal.

These dysfunctional loading forces are promptly transferred bi-laterally to the quarters of the hoof instigating trauma at the lamina interface. The consequences of this trauma result in the lamina disconnecting from the outer hoof capsule. This disconnection internally is observed externally as the commencement of hoof flares. The hoof capsule continues to slide forward stretching the dorsal toe and triggering internal miss alignment and increased pressure on the dorsal and distal corium areas of the hoof. This is often the beginning of seedy toe. The foot now endeavours to fuse all parts together by laying down extra sole material to reduce internal movement and prolong the soundness of the animal.

As the palmar section of the foot reaches a critical point of dysfunction it commences to work against itself. Normally movement by the horse requires the palmar section of the hoof to expand on impact with the ground. Instead, inappropriate loading forces cause the distal cartilages to implode on the digital cushion and other sensitive distal structures (interphalangeal joint, internal bars and distal artery, vain and nerve supplies). These inappropriate loading forces trigger the distal cartilages to be drawn in instead of appropriately expanding the palmar hoof section on impact with the ground. This dysfunctional incorrect inward movement of the distal cartilage places pressure on the distal phalangeal artery reducing the vascular flow to the hoof. The animal also develops an improper palmar digital neuropathy due to pressure changes from the collapsing distal cartilages. These incorrect biomechanical forces, vascular infusion and neuropaths of the hoof all translate into foot pain and the animal then changes its posture and orthopaedic balance. After the orthopaedic stance of the animal is compromised the inappropriate loading forces instigate a neuromuscular response which triggers the muscular- skeletal system to adapt due to the incorrect pressure it is faced with.

Assessing the digital cushion

Appreciating the importance of this major component of the hoof, the author has been working on formulating a procedure for checking the alignment and vascular volume of the digital cushion. The only way to do this without being invasive to the animal is through palpating the area for alignment and the tissue for texture.

To carry out this palpation the practitioner should

- Place your thumb between the bulbs of the heel on the same angle as the pastern at the back of the hoof and your forefinger on the surface of the frog.
- Palpate this area similar to using a set of hoof testers. The digital cushion should have a pliable, smooth and slightly raised centre. When compressed it should apply a slight bilateral outwards pressure on the distal cartilages.
- An unhealthy digital cushion feels like either hard or has a jelly like consistency which

depends on the type of dysfunction. It sits medial laterally protruding into the area of the distal cartilage. When normal loading forces are applied to the foot by movement the digital cushion collapses and draws the distal cartilage inwards. Incorrect pressure is also placed on the corium of the sole and other sensitive internal structures of the foot, causing palmer hoof pain and orthopaedic stance change.

It is due to this reduced ability of the palmar section of the hoof being able to maintain its correct internal relationship with the hoof capsule that we have so many orthopaedic problems. *Thus, the digital cushion should be considered more when determining lameness or hoof pain in the horse.*

Consequences of Orthopaedic Balance

It is vital that the practitioner has the ability to recognise the changing stance of the animal and the changes that are transpiring in the muscular skeletal alignment of the upper torso, to comprehend the consequences of the orthopaedic balance of the animal.

The horse has the ability to transfer weight from side to side in addition to forward and backwards and it is this inherent ability that will affect loading through the hooves. It is important to understand that the muscles used in movement are located a long way above the hooves and that a well-developed system of tendons, muscles and ligaments connect the hooves to the upper body. These systems need to be robust and in correct alignment to allow for optimal function, coordination and proprioception.

This inherent ability for weight transfer has the capacity to influence hoof capsule alignment or muscular skeletal stress throughout the horse's body. It is always a challenge for the practitioner to find the directional nature of the dysfunction. Is the inappropriate weight transferred from the hooves to the upper body or is it transferred from the upper body to the hooves?

When there is any dysfunction in the horse, the stress related changes in the animal will trigger modifications in the foot shape and/or notable shifts in the forces applied to the muscular skeletal system as well the function of locomotion. The stress in either hoof or upper body intensifies the tissue and structural changes, and these resultant changes can be seen by the naked eye on the external surface of the animal. These structural deviations are termed pathological, meaning that there is an alteration in tissue structure and shape. These can be readily identified by the proficient practitioner.

As with all pathology it is hard to distinguish what is underlying the external signs. External pathology is really a change in the cellular makeup of the underlying tissue or structure. This is usually known as histopathology. Professor Chris Pollitt and Professor Robert Bowker have studied the histopathology in the hoof extensively. It is this pathology transformation internally that presents itself as a modification in the external tissue that will give the practitioner a guidance to understand the forces affecting the horse's body. It is this appreciation of the transforming pathology which allows the author to form an opinion as to the individual tissue and structures that are under stress and the modifications needed to return function to the cellular level of the animal for an optimal outcome.

The hoof is constantly under pressure while performing its function as shock absorber, protector of the internal structure of the hoof and weight supporter of the horse. A horse's structural system works extremely well if gravitational forces travel through the appropriate orthopaedic alignment. However, an imbalance in these forces can and will produce a breakdown or reactionary misalignment in the internal hoof structure. Many of the changes caused by this inappropriate orthopaedic alignment can be understood by a close and thorough examination of the external hoof structure. A further consequence of this is incorrect loading of the muscular-skeletal system as it attempts to compensate for a dysfunctional system. An understanding of the transforming pathology is known as "Equine Orthopaedic Balance" ® because it refers to the entire musculoskeletal system in motion and at rest and not just the hoof pastern axis alignment.

It is essential to have a comprehension of the fulcrum effect on the distal interphalangeal joint (distal sesamoid, distal phalanx and middle phalanx) along with other associated structures of the lower limbs when assessing the muscular-skeletal system of the horse. The practitioner has a lot to consider, when looking at the forces (gravitational or mechanical) on the internal structures of the feet and the interrelated forces acting on the orthopaedic stance of the animal. These inappropriate interrelated forces being stationed on pain sensitive structures being bones, distal cartilages, ligaments, lamina interface and vascular components of the hoof, can trigger the horse to alter its orthopaedic stance and functional movement patterns.

Upper body areas are affected by incorrect hoof balance or axis.

Horses which have unsuitable hoof balance or axis in their front hooves develop problems with their thoracic-lumber area, causing their top line to drop away. Confirmation of this incorrect hoof balance in the hind hooves usually show up in the lower-lumber and sacral areas triggering the horse to change its stance.

The horse that is affected with a less than optimal hoof balance in the forelimbs will produce a compensation pattern of altering their stance on the hind limbs. This is due to the offloading of the sensitive structures in the front part of the animal and the need to redistribute their weight more into the hind segment.

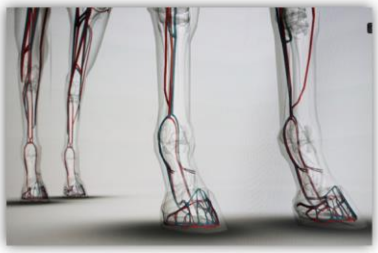


Photo by 3 D Horse Anatomy

If the front limbs are observed rotating inwards the horse tends to have problems in the ribs and chest area as this does not allow for suitable suspension of the vertebral column between the scapulars.

A horse which presents with a high head carriage tends to place a lot of tension on the upper torso attachments at the base of the neck and withers. This will also have an effect on the skeletal muscles, ligaments and nerves of the front limbs (especially around C6-7 and T1).

In some cases, the author has observed that the hind hooves tend to travel outside the alignment of the front limbs due to tightness in the loins area. This is triggered by the misalignment of the front limbs.

It is therefore very important that the practitioner looks over the entire horse to establish its conformation and to see if there is any rotation of the bones supporting the lower limbs. If it is established that the main conformation of the animal is found to be sound, then the practitioner's thoughts should be to observe the alignment of the individual limbs.

Observe the individual forelimbs first and ensure that the radius is in line with the body of the horse. The ulna should not face into or away from the body. Establish if the hooves toe in or out of alignment with the distal structures. Observe each individual limb laterally to check if the knee alignment is correct or if it is pushed forward.

Use the same process with the hind legs. Observe if the hocks face in or out, is the patella in line with the body or not, do the toes turn in or out. Misalignment in the bone of the hind leg (femur/tibia/pelvis) can produce problems like locking stifles, shorting of the hamstrings and pressure being placed on the spinal column and nerve system.


Photo by 3 D Horse Anatomy

If the observation is the bones of the limb are misaligned, then it can usually be traced back to the hoof balance or axis. As the hoof impacts with the ground the resultant loading stress placed on the bones and joints of the hooves striking the ground unequally will produce varying degrees of bone rotation and muscle tension throughout the horse's body. This will have varying affects at the point of muscle attachment to the bones and over long periods it can cause abnormal muscle development. The practitioner should keep in mind that the horse's weight has to transfer down through the limbs to the ground and if they are not positioned in alignment with the body then weight is transferred to the ground unevenly. The ramifications could be perceived swelling at the coronet and/or fetlock joint or even the distal structures of the limb.

Conclusion

Unfortunately hoof problems are just the beginning of associated problems in the horse. How the horse deals with these problems is seen throughout its entire body as incorrect changes in orthopaedic balance. These changes can range from subtle movement patterns to avoid pain to dramatic alterations in movement, performance and behaviour. The clues as to how the equine copes with hoof related problems is found throughout its entire body. A careful examination of transforming muscular tension in association with the hoof pathology is required to fully ascertain the severity of a problem/s.

To understand a complex structural and functional podiatry problem the practitioner should identify the external pathology of the foot by considering the texture, size, colour, shape and alignment of each individual hoof area and ensure it is coping with the forces and stresses placed upon it.

Acquiring the ability to interpret if the structures are out of alignment is having the knowledge to interpret the pathology of the structures and the practitioner ought to keep this foremost in their mind whenever commencing an examination or formulating a treatment strategy.

Considering how and why the problem has occurred and acquiring the ability to interpret the orthopaedic balance and response of the animal is one of the keys to a broad range of equine problems.

The key to foal structural soundness is early diagnosis and correct structural intervention to minimise these types of deviations and dysfunctional systems in the foal and the adult horse.

This is the case for early intervention which should maximise the success and integrity of the structures involved and thus the future development of a sound horse.

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