Diagnosis and Treatment of Limb Deformities in Foals

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Introduction

Limb deformities in foals can be subdivided into two major groups: 1) angular limb deformities, in which there is deviation, primarily in the frontal plane, originating at a joint and/or growth plate; and 2) flexural limb deformities, in which there is persistent hyperflexion or hyperextension of the limb. These conditions are generally categorized under the umbrella term of developmental orthopedic diseases, which also includes physitis, incomplete ossification of cuboidal bones, osteochondrosis dissecans, and subchondral bone cysts. Both angular and flexural deformities may be congenital or acquired, and their etiology is likely multifactorial. Regardless of the underlying cause, however, early appropriate intervention is the key to the best outcome in these cases.

Angular Limb Deformities (ALD)

Ossification of the appendicular skeleton occurs relatively late in gestation, with partial ossification of the diaphyses/metaphyses of long bones not occurring until 230 days. By 260 days of gestation, the distal epiphyseal ossification centers start to appear, and by 290 days, the proximal epiphyseal ossification centers appear. It is not until 300 days that all bones of the carpus/tarsus are visible radiographically, and ossification of these cuboidal bones progresses towards the periphery as parturition approaches. A complex molecular signaling cascade regulates endochondral ossification, and any disturbance of this process can lead to developmental orthopedic disease. When this disturbance occurs in the physis, it can lead to ALD and physitis; when it occurs in the cuboidal bones of the carpus/tarsus, it can lead to incomplete ossification of these structures and the risk of cuboidal bone crushing and subsequent ALD.

ALD involve lateral (valgus) or medial (varus) deviation relative to the long axis of the bone in the frontal plane. They are named by the joint involved and the direction of the deformity, e.g. carpus valgus (**Figure 1**). There is often also a degree of rotational deformity involved. The most commonly affected locations are the distal radius/carpus, the distal tibia/tarsus, and the metacarpo-/tarsophalangeal joints. Carpus valgus is the most commonly reported condition, followed by fetlock valgus/varus. Most foals are born with some degree of angular deformity; however most are mild and correct without surgical intervention within the first few weeks of life. For example, in one large study of Thoroughbreds, 62% of foals were diagnosed with ALD, but only 5.4% required treatment.

Figure 1: Severe carpus valgus.

A number of factors have been identified as playing a role in the etiology of ALD. Perinatal factors include flaccidity of periarticular soft tissue structures and incomplete ossification of cuboidal bones combined with uneven loading of the joint. Developmental factors include unbalanced nutrition, which can lead to aberrant growth at the level of the physis, excessive exercise or overload of a limb, and external trauma, particularly a physeal fracture or crushing injury, which can lead to premature closure of the

physis. ALD that manifest at the time of birth and are due to perinatal factors are often manually correctable in the early stages, while those that appear later in life and are due primarily to developmental factors are generally not manually correctable.

Foals with periarticular laxity are often referred to as “windswept” and they may switch between varus/valgus based on limb position and weightbearing. These deformities often affect multiple joints, and concurrent rotational deformities are not uncommon. In foals with normally ossified cuboidal bones, the “windswept” conformation may resolve with mild exercise in a few weeks. However, if periarticular laxity is combined with incomplete ossification of cuboidal bones, serious permanent deformities can develop. Therefore, radiographic assessment of “windswept” foals is always recommended.

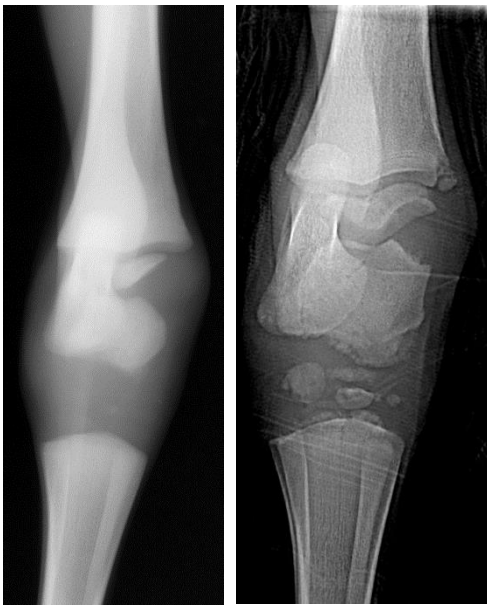

Figure 2: Tarsus of a twin foal at birth (left) and 30 days of age (right). Note the progression of ossification of the distal tarsal bones.

Incomplete ossification has been associated with prematurity/dysmaturity, twin births, hypothyroidism and a number of health conditions affecting the mare, notably placentitis, chronic metabolic disease, heavy parasite load, and colic. Crushing of incomplete cuboidal bones must be avoided to prevent long-term adverse effects, including permanent ALD and degenerative joint disease. Incompletely ossified cuboidal bones can be recognized radiographically by their rounded appearance, in contrast to the normal “squared-off” shape. A variable amount of space between bones may be present, reflecting varied degrees of ossification. In the most severe cases, the cuboidal bones may appear almost absent (**Figure 2**). Foals with crushed tarsal bones exhibit a classic “bunny hop” gait and are less likely to be successful as athletes, even with surgical intervention to try to correct the resulting ALD. Treatment for incomplete ossification should be initiated as close to the time of birth as possible and consists of the application of casts and/or splints combined with stall confinement. The duration of treatment will vary depending on the severity of the condition, but may be 2 weeks to 2 months or longer. Regular radiographs are recommended to monitor progress, and casts/splints must be changed frequently to accommodate the growth of the foal and avoid the development of sores. Ideally, the foot should be left out of the cast/splint so that the muscles and tendons are not weakened, Foals can be treated successfully with the foot incorporated, but with the understanding that there will be some temporary flexural laxity once the splint/cast is removed.

Diagnosing ALD

Initial diagnosis of ALD is generally made on the basis of clinical examination. If a rotational deformity is also present, it is important to judge the angular deformity while standing aligned with the foot rather than the body so as not to overestimate the severity of the ALD. For example, if viewed from directly in front of the foal, external rotation can make a valgus deformity look more severe than it actually is. External rotation of the forelimbs will often correct on its own as the chest broadens and strengthens with age. Importantly, if the carpus/tarsus are

externally rotated while the foot faces forward, then a compensatory varus deformity of the fetlock is present that may become permanent if not noticed and corrected before 3 or 4 months of age.

Radiographic diagnosis of ALD is best made using a single dorsopalmar/-plantar view taken using a long plate so that the bones proximal and distal to the deformity can be included. This allows for the degree and origin of the deformity to be defined. Lines are drawn through the long axes of the bones adjacent to the deformity; the point of intersection is considered to indicate the site or source of the deviation.

Treating ALD

Treatment for ALD may be conservative or surgical. Selection of treatment depends on the severity and location of the lesion and the age of the foal (**Table 1**). For example, conservative therapy is more likely to be successful for mild deformities in younger foals. Conservative treatment includes restricted exercise (crucial for cases of incomplete ossification), corrective hoof trimming/shoeing, splints and casts, and nutritional support, including providing appropriate energy levels and balanced minerals. Surgical options include periosteal stripping, growth retardation via transphyseal bridging or a transphyseal screw, and corrective osteotomy.

Table 1: Recommendations for timing of interventions (maximal age) for ALD in the foal.

Joint	Conservative Treatment	Periosteal Stripping	Transphyseal Bridging	Cessation of Growth
Fetlock	< 2-3 weeks	< 2 months	< 3 months	6-15 months
Tarsus	< 2-3 months	< 4 months	< 10 months	17-24 months
Carpus	< 3-4 months	< 4 months	< 12 months	22-36 months

Hoof trimming is often the first line treatment for very young foals, but is not appropriate as the sole treatment for older foals. As the hoof walls grow to accommodate the angular deformity, the abnormal hoof shape tends to reinforce the deformity. Thus, in valgus deformity the outer hoof wall tends to be longer and should be rasped down, while in varus deformity, the inner wall needs to be rasped. Trimming should be conservative, taking only a small amount of hoof at a time, but frequent. In cases where trimming alone is insufficient, offset shoes may be placed to realign the limb's longitudinal axis of loading. These can be difficult to keep on the foal; filling in the space between the edge of the extension and the hoof wall with acrylic can help to prevent the other foot from stepping on the shoe and pulling it off. These shoes must be changed frequently as the foal grows. Attempts at deformity correction with either trimming or shoeing should not be attempted for a prolonged period of time so as not to miss the window of opportunity for surgical management. Both can also be used as an adjunct to surgical intervention.

The concept of growth acceleration via hemi-circumferential periosteal transection and elevation ("periosteal stripping") to correct angular limb deformities was introduced in the early 1980s. The idea behind this technique is that by transecting the periosteum on the concave side of the limb, it removes any restriction of the physeal growth, allowing it to "catch up" to the other side. The major advantages of this procedure are that it is rapid (often performed on an outpatient basis), has few reported complications, and cannot result in "overcorrection" of the treated limb. For many years, this procedure was extremely popular; however, more recent

studies have called its effectiveness into question. In the first study, foals had bilateral carpus valgus induced surgically, while in the second, foals with naturally-occurring bilateral carpus valgus were used. In both cases, one leg was treated with periosteal stripping while the other was left untreated; foot trimming was applied in both forelimbs and the foals were stall-rested. In both studies, the carpus valgus corrected whether or not periosteal stripping was used.

For more severe lesions, or in older foals (i.e. after rapid growth phase is over), transphyseal bridging techniques are preferred. These are applied to the convex side of the limb and restrict growth on that side of the physis. Initially, plates and staples were used, but these have fallen out of favor due to undesirable side effects (i.e. significant cosmetic blemishes, implant failure). Transphysieal bridging using a screw and wire is currently the most popular approach, although use of a single transphyseal screw has been advocated as a minimally invasive technique. However, the consequences to ongoing growth from the implant passing through the physis is unknown, and as a result this technique is generally reserved for foals reaching the end of their growth phase. Regardless of the technique used, it is crucial to closely monitor foals undergoing transphyseal bridging as the implants must be removed before the limb is perfectly straight to prevent over-correction. Serial radiographs to monitor progress are highly recommended.

In cases where there is not sufficient growth left to accommodate the ALD, or if the deformity originates from the middle of a long bone, a corrective osteotomy/ostectomy is the only remaining treatment option. Of the reported ostectomy techniques, the step ostectomy is preferred because both rotational and angular deviations can be addressed at the same time. This is not a simple procedure and is rarely performed, but successful outcomes have been described in the literature.

Prognosis for ALD

Published reports suggest that prognosis is better for foals with carpal ALD (80-85% successful outcome) than for tarsal ALD (~50%), and that it is the worst for foals with fetlock deformities (27%). In part, this may be due to delayed intervention for fetlock lesions; once the short window of growth closes there is little that can be done for these foals. Foals with collapse of cuboidal bones do not respond as well to treatment as those without collapse, emphasizing the importance of early intervention for this condition as well.

Flexural Limb Deformities (FLD)

Flexural limb deformities refer to persistent hyperextension or hyperflexion of a joint – essentially, an angular limb deformity in the sagittal plane. Hyperflexion is commonly referred to as “contracted tendons”, although this is a misnomer since there is not actual contracture of the tendon. Instead, the tendon units are too short relative to their associated bones. FLD may be present at birth (congenital) or can develop any time throughout life. These acquired deformities occur most commonly during times of rapid growth, between 4 weeks and 4 months of age, and around 1 year of age. FLD are much more common in the forelimb than the hindlimb, with the most commonly affected joints being the distal interphalangeal (coffin), metacarpophalangeal (fetlock), and carpus.

As with ALD, the etiology of FLD is multifactorial and may involve congenital and acquired factors. Congenital factors that have been reported to be associated with FLD include teratogenic agents, ingestion of locoweed or Sudan grass by the mare, gestational diseases (e.g. influenza), intrauterine positioning, and genetic risk factors. Some FLD fall within the

category of developmental orthopedic disease, and therefore nutrition, particularly excessive intake, abrupt change in quality of intake, and mineral imbalance, may play a role in their development. Infectious polyarthritis and trauma can also lead to the development of FLD, as can any painful condition that causes prolonged reduced weightbearing. FLD can develop extremely rapidly, particularly in young foals, and can become permanent without timely intervention.

Digital hyperextension, also referred to as flexor tendon laxity, is seen to varying degrees in many newborn foals. Generally, these foals exhibit no radiographic abnormalities and controlled exercise will correct the problem within the first few weeks of life. If necessary, heel extensions can be placed to help restore a more normal pastern alignment, but these can be hard to keep in place. It is vitally important that this condition *not* be treated with splints or bandages, as this will only make the laxity worse. If the foal is walking on the palmar/plantar aspect of the pastern and fetlock, then a light bandage can be placed to protect the skin from abrasion. Extensor tendon contracture may look similar to digital hyperextension, but with restricted range of motion of the affected joints rather than laxity. This is a rare condition that typically occurs as part of a complex of deformities, and conservative treatment similar to that used in conditions affecting the flexor tendons can be attempted.

Rupture of the common digital extensor tendon is a congenital condition that presents with a characteristic swelling in the tendon sheath on the dorsolateral aspect of the carpus and a bowlegged stance. When an affected foal walks, it must throw its leg forward, and may knuckle at the fetlock and/or carpus when bearing weight on the affected limb. The condition is frequently bilateral and is commonly seen in conjunction with incomplete ossification of cuboidal bones, so radiographic assessment of foals with this condition is recommended. Surgical intervention is not recommended for this condition; stall rest and splinting or casting should be maintained until the swelling does not return, typically 2-4 weeks.

FLD of the coffin joint is commonly referred to as a “clubbed foot” and is associated with the deep digital flexor tendon (DDFT). Mild, early cases may simply appear more upright than a normal foot, with a steep dorsal hoof wall and short toe. With time, the foot takes on a classic boxy appearance with the heel similar in height to the dorsal hoof wall. The toe becomes excessively worn, and the heel may not touch the ground when the horse walks. Over time, coffin bone (P3) remodeling occurs (**Figure 3**). Coffin joint contracture has been divided into two stages, based on the angle between the dorsal hoof wall and the ground. Stage I deformities have a dorsal hoof wall angle < 90° and are generally expected to have a good prognosis with treatment. Stage II deformities have a dorsal hoof wall angle ≥ 90° and carry a guarded to poor prognosis.

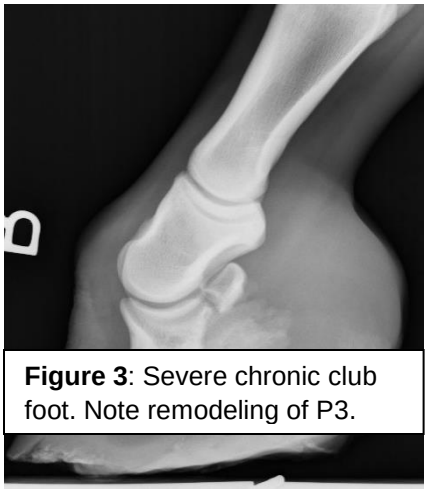

Figure 3: Severe chronic club foot. Note remodeling of P3.

Horses with contracture of the metacarpophalangeal joint have an upright fetlock angle and may develop degenerative joint disease at a young age due to the abnormal forces being placed on the joint. In severe cases, the foal may be unable to extend the fetlock at all and walk on the dorsum of the joint. Fetlock contracture may be reducible or non-reducible; this should be evaluated when the limb is non-weightbearing. Placing pressure on the dorsal aspect of the joint

will tense the flexor tendons, and an evaluation can be made as to which structure is the tightest – superficial digital flexor tendon (SDFT), DDFT, or suspensory ligament. This is important because it will affect treatment selection.

Foals with carpal flexural deformities may be able to stand but buckle at the carpus; alternatively they may be recumbent and unable to rise. In these more severe cases, the contracture is often irreducible and the prognosis guarded (although cure is possible in some cases). If manual reduction is possible, then the prognosis is generally good. Any foal with contracture involving the carpus should be evaluated radiographically for incomplete ossification of the cuboidal bones and treated appropriately for that condition. Fortunately, the same treatment approach (casting/splinting) is appropriate for both! Carpal contracture may be seen as a single condition, but commonly occurs in combination with flexural deformities of the lower limb.

Treatment of FLD

The ease of manual correction of a FLD generally correlates with the prognosis for response to conservative therapy. Additionally, earlier intervention is more likely to result in a good outcome. The mainstays of conservative treatment for FLD are limited controlled exercise, nursing care as needed for recumbent foals, manipulation of the foot with trimming/shoes, splinting/casting, and pain management (primarily non-steroidal anti-inflammatory drugs). In cases of acquired FLD, nutritional imbalances should be addressed if present.

In newborn foals, administration of oxytetracycline has been used as a treatment for FLD. Musculotendinous unit relaxation is thought to be caused primarily by calcium ion chelation in the myofibroblasts in the distal check ligament and deep digital flexor tendon, although a MMP-1 mediated mechanism has also been proposed. The response to oxytetracycline can be dramatic and is generally rapid (within 24-48 hours), but may be transient: in one study, foal conformation returned to pre-treatment measurements within 96 hours after treatment. Therefore, oxytetracycline is often used in combination with other treatments, such as splinting, for a more prolonged response. Administration can be repeated two or three times within the first few weeks of life, but the response seems to lessen with age. This may be due to maturation of the extracellular matrix, but this has not been shown conclusively.

Manipulation of the foot is aimed at forcing the tendons to stretch. This is achieved by lowering the heel and placing toe extensions. Toe extensions also help to protect the toe from excessive wear. If a foal is recumbent, a similar effect can be achieved by physically stretching the tendons several times a day. This manipulation of the tendons can be painful, so administration of analgesics is important to address this discomfort, as well as to address any underlying painful condition that may have initiated the FLD.

Splints/casts allow for continuous active stretching of tendons. Simultaneously, the immobilization and relief from loading results in tendon relaxation. It is crucial that casts/splints be monitored very closely to avoid the development of sores and their sequelae. Casts should be changed at least every two weeks to accommodate the growth of the foal, while splints must be well-padded with bandaging that is changed every 3-5 days. For deformities of the carpus and fetlock, the feet are ideally left out of the cast/splint. Most congenital flexural deformities respond well to splinting/casting (plus other conservative therapy) and may resolve in as little as 10-14 days.

Figure 4: Same horse as in Figure 3, 60 days after transection of DDFT. Corrective trimming has also been performed

Surgical intervention is typically recommended when conservative treatment is not effective, or for severe or rapidly worsening deformities. The primary goal of surgery is to release tension in the restrictive musculotendinous unit, allowing for greater stretch and a more normal range of motion of the affected joint. For coffin joint flexural deformities, the treatment of choice is transection of the inferior check ligament (accessory ligament of the DDFT); however, severe cases may require transection of the DDFT (**Figure 4**). DDFT tenotomy has been traditionally thought of as a salvage procedure, but there have been reports of horses being sound enough to ride following this treatment.

For fetlock joint flexural deformities, transection of the superior check ligament (accessory ligament of the SDFT) is typically performed first, with inferior check ligament desmotomy added if tension in the DDFT continues to prevent normal motion in the fetlock. A number of surgical approaches have been described for superior check ligament desmotomy, including tenoscopic and ultrasound-guided, as well as the traditional open approach. Severe cases of carpal contracture may require transection of the ulnaris lateralis and flexor carpi ulnaris. In all cases, surgical correction must be augmented with appropriate bandaging/splinting and controlled exercise to maintain the improvement seen in the immediate post-operative period. The most common complications noted after surgery are persistent hematoma, surgical site infection, and cosmetic blemishes.

Prognosis for FLD

The majority of congenital FLD respond to conservative therapy and carry an excellent prognosis. Similarly, acquired deformities that are identified early and promptly treated tend to have good outcomes. Among lesions that require surgical intervention, there are mixed reports. In Thoroughbreds and Standardbreds undergoing desmotomy of the inferior check ligament, between 50-80% went on to race. In a mixed population of horses with acquired fetlock flexural deformities treated surgically, those with mild or moderate lesions were able to return to work, while those with severe lesions could not. Treatment of foals with carpal contracture was more successful for those with mild lesions, but the overall success rate was still high (72-86%). In most studies, foals in which intervention was performed at an early age did better than those in which treatment was delayed.

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