Angular Limb Deformities
Growth Augmentation

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KEYWORDS

• Foal • Growth plate • Valgus • Varus • Periosteal transection • Elevation

KEY POINTS

- The most common angular limb deviation seen in the foal include carpal or tarsal valgus and fetlock varus.
- Angular limb deformities (ALDs) or deviations are common in young foals, with most deviations able to self-correct with minimal intervention, including modifications in exercise.
- Trimming of the hoof can be highly effective in cases of mild deviations; for valgus or varus deviations, the lateral or medial aspect of the hoof is trimmed, respectively.
- Hemicircumferential transection and elevation (periosteal stripping procedure) are performed on the concave aspect of the deviation.

ALDs are commonly seen in young foals and are defined as lateral or medial axial deviations of the limb in the frontal plane distal to a particular joint. A carpus valgus deformity refers to a lateral deviation of the limb distal to the carpus in relation to the limb proximal to this joint (**Fig. 1**). On the other hand, a fetlock varus deformity refers to a medial deviation distal to the fetlock in relation to the rest of the limb proximal to the fetlock (**Fig. 2**). Foals affected by a valgus deformity commonly exhibit a toed-out conformation and those affected with varus deformity exhibit a toed-in conformation.

RISK FACTORS

Risk factors commonly associated with ALD include perinatal factors, such as premature birth, twin pregnancy, placentitis, perinatal soft tissue trauma, and flaccidity of the soft tissue structures surrounding the joints.[1–4] These factors can potentially lead to incomplete ossification of the cuboidal bones of the carpi and tarsi (**Fig. 3**) and excessive laxity of the joints. Normally, most foals are born with some degree of limb deviation, mostly due to ligament laxity and muscle weakness, which usually corrects itself

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Fig. 1. Frontal view of a foal with bilateral carpus valgus deformity. (*Courtesy of* Dr Gustavo Abuja, LV, DACVS, Rhinebeck Equine Hospital, Rhinebeck, NY.)

as the foal matures and exercises.[1,2,4] If incomplete ossification of the cuboidal bones is present and not adequately recognized, however, affected foals run the risk of having these small bones crushed from exercise and the uneven load that is placed on the joint due to laxity. Once ossification occurs, an ALD results due to the crushing and resulting abnormally shaped cuboidal bones. To minimize this risk, limited and strictly controlled exercise encourages appropriate ossification. If a foal's activity cannot be strictly managed and the foal has moderate strength, sleeve casts are recommended to prevent cuboidal bone crush. Sleeve casts should be changed or removed in 10 days to 14 days in a growing foal. Radiographic re-evaluation every 2 weeks helps determine the length of time a cast is required.[2] Incomplete ossification is discussed by Michelle C. Coleman and Canaan Whitfield-Cargile's article, "Orthopedic Conditions of the Premature and Dysmature Foal," in this issue.

In addition, developmental and acquired factors, such as unbalanced nutrition, excessive growth rate, and excessive exercise and/or trauma, can result in ALD in older foals.[1–3] Crib feeding of foals may lead to excessive grain intake by the dominant foals, creating an imbalance in their diet, in particular, an excess of carbohydrates and protein intake. Nutritional imbalance may cause disproportionate growth across the growth plate, thus causing the deviation. Exercise is an important element in the proper development and growth of foals. If the amount of exercise is excessive, however, this trauma can lead to microfractures and crushing of the growth plate, which cause the development of ALD.[1,2]

Fig. 2. Frontal view of a foal with marked right front fetlock varus deformity.

CLINICAL EXAMINATION AND RADIOGRAPHY

Deformities can be assessed subjectively by visual examination. The foal should stand as squarely as possible, with the foot directly below the proximal part of the limb. Deviations from this stance exacerbate any deformities that truly present. Repositioning foals several times to evaluate each limb independently is often necessary because they often only stand still for short periods of time. This allows observation of how a foal stands most frequently in a relaxed position. The clinician stands directly in front of the dorsum of the long bones for evaluation of the forelimbs, not necessarily at the front of the toe. The forelimbs can also be evaluated by standing shoulder to shoulder with the foal, looking down the limb toward the ground. The orientation of the toe may be affected by a concurrent rotational deformity, which confounds interpretation. Hind limbs should be evaluated similarly but directly from behind.[2] All limbs also should be evaluated with the foal walking away from and toward the clinician. Breakover is determined for each foot, which may be helpful in deciding the most appropriate way to manage the foal. The entire assessment of a foal should be graded and recorded on video or on paper for future reference.

Radiography provides an objective assessment of angular deformity (**Fig. 4**), but sequential radiography may be unreliable if the obliquity varies. Differences in radiographic projection can result in a misinterpretation of worsening or improvement, which is particularly true when trying to quantify small differences in the angle. Radiography is essential to identify cuboidal injury or malformation (see **Fig. 3**). Such a deformity dramatically worsens a foal's prognosis. Foals with angular deformity

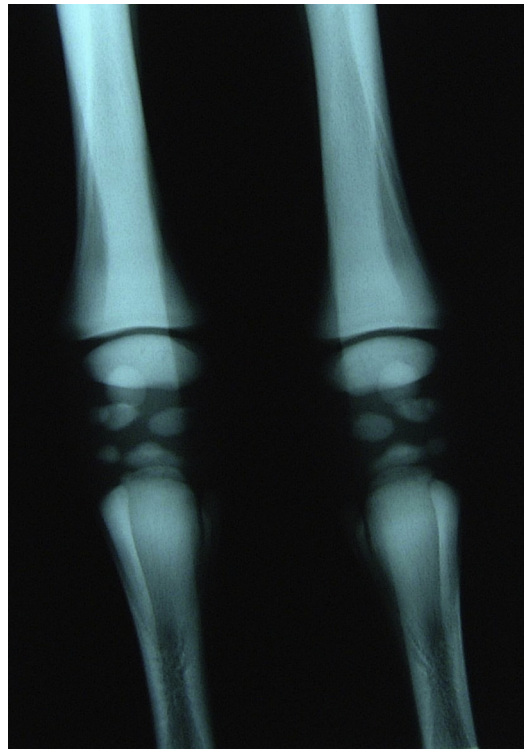

Fig. 3. Dorsopalmar radiographic view of a carpus with mild incomplete ossification of the carpal bones and valgus deformity.

resulting from cuboidal bone abnormalities usually have compromised range of motion, but this often is detected best with a foal in lateral recumbency.[2]

Growth rates are most rapid in the neonate and slow considerably within the first year. Most of the growth from the distal radial and tibial physes is within the first 6 months of age. Most of the growth from the distal third metacarpal (McIII) and third metatarsal (MtIII) bones is within the first 3 months of age. Minimal changes take place beyond this age. Radiography alone cannot be used to determine the end of bone growth, because the physis is radiographically apparent long after clinically relevant growth has abated. A normal foal should correct a carpus valgus to within 5° to 7° of normal by 4 months of age and should be almost straight by 8 months to 10 months of age.[2]

MEDICAL MANAGEMENT

Periarticular laxity is the major cause of congenital ALDs and often improves dramatically within the first 4 weeks of life, without any intervention, because the periarticular tissues become less elastic. The improvement is most dramatic in a windswept foal, which has a tarsus valgus of one limb and a concurrent varus of the other. Limited exercise is all that is required for these foals to become normal.[2,4]

Infrequently the deformity can be so severe, particularly in the fetlock, that a foal is unable to bear weight on the sole of its foot. Immediate treatment is required to establish normal weight bearing. Custom-made glue-on shoes are particularly useful to

Fig. 4. Dorsopalmar radiographic view of a carpus with valgus deformity. Lateral is to the right.

prevent abnormal breakover and to keep the foot flat on the ground. If a foal has excessive laxity of the lateral collateral ligaments and a tendency to break over on the lateral side of the foot, a lateral extension shoe is used to maintain appropriate alignment of the limb.[2] The foal should initially be restricted to a stall before turnout in a small paddock or round pen with just the mare. Soft tissues become progressively stronger, and normal activity can be permitted within a short time. Allowing premature excessive exercise can lead to proximal sesamoid bone fractures and other injuries. Glue-on shoes are usually required for several weeks, but they then should be removed to avoid contracture of the foot. External coaptation also should be avoided if possible. Splints are used only to maintain joint alignment if absolutely necessary. Splints are contraindicated to try to pull or push a limb straight. Rigid support from a splint or cast usually leads to greater soft tissue laxity.[2] Trying to support a limb results in continued laxity and soft tissue wounds from bandaging. Every foal must be managed on an individual basis with the goal of achieving normal weight bearing and function while providing the minimal amount of support necessary.

Asymmetric growth of a distal physis is a cause of ALD. Greater growth from the distal physis of the radius medially compared with growth laterally results in carpus valgus.[2] Continued asymmetric growth precludes the normal correction anticipated with resolution of periarticular laxity. Greater growth from the lateral distal physes of the McIII or MtIII bones results in fetlock varus. With time and limited exercise (stall

or small paddock turnout, alone with the mare) substantial self-correction occurs for most foals with angular deformities. Radiography can be used to evaluate objectively the degree of deformity and the difference in physeal growth, but it is not always required.[2]

In most situations, judicious minimal intervention is all that is required to ALDs.[2,4] Surgical intervention should be reserved for those foals that are not improving fast enough for the amount of growth potential remaining or have a severe deformity.[2,4] Therefore, it is critical for frequent re-evaluation of a foal with an ALD to monitor progress. Surgical intervention has a greater effect on a young foal because of the more rapid growth; thus, early surgical intervention should be considered for a foal with a severe deformity.[2]

SURGICAL MANAGEMENT

A high proportion of foals with ALDs are treated successfully conservatively, but surgical intervention is warranted if a deviation is severe or if deformity persists despite adequate management, including restriction of exercise and corrective farriery.[2] A variety of surgical techniques aimed at accelerating or decreasing the growth on a particular side of the growth plate have been described.[1–8] Surgical technique, whether aimed at accelerated or restricted growth, depends on the age of the horse, the degree of ALD, the anatomic site, and whether the deformity is varus or valgus.[1–8] This article focuses on growth augmentation techniques.

Before surgery, all the limbs should be assessed from the front and back and while standing next to the limbs. Good-quality radiographs, which include a substantial length of the bones proximal and distal to the deviation, should be obtained to assess bone structure (see **Fig. 4**) and to determine the pivot point and pivot point angle of the deviation.[2] The pivot point is the intersection of 2 lines drawn parallel to the long axis of the bones proximal and distal to the articulation in question. The pivot point indicates the origin of the deviation and helps determine whether the cuboidal bones, in cases of the carpus and tarsus, are involved in the deviation, or if deviation is caused by disproportionate physeal growth only (**Fig. 5**).[2] Abnormalities in the structure of these bones can have a substantial influence on the effect of the procedure and the future athletic potential of the horse. The pivot point angle is the angle formed by the intersection of these 2 lines and indicates the severity of the condition.[9]

Hemicircumferential periosteal transection and elevation, or periosteal stripping, aim to accelerate growth on the concave side of the limb, laterally for valgus and medially for varus deformities.[1–4] Previous work on chicken radii had shown that a circumferential division of the periosteum, rather than a longitudinal one, resulted in increased bone growth. The proposal was that the periosteum functioned as a fibroelastic tube, which spanned the diaphysis and provided an even tension between both epiphyses, that was responsible for the regulation of growth.[1,10] A horizontal or circumferential division of the periosteum would result in a release of tension at the level of the growth plate, resulting in the induction of new bone production on the side of the division.[10]

Hemicircumferential periosteal transection and elevation (aka Periosteal Stripping) has been thoroughly described in the literature[1–8,11] and can be performed alone or in combination with growth retardation techniques described by Taralyn M. McCarrel's article, "ALD: Growth Retardation," in this issue. To summarize, hemicircumferential periosteal transection and elevation are performed with the foal in lateral recumbency under general anesthesia, with the concave side of the affected limb uppermost. If the procedure is going to be performed bilaterally, dorsal recumbency is recommended. The position of the physis, which in carpal deviations can be generally

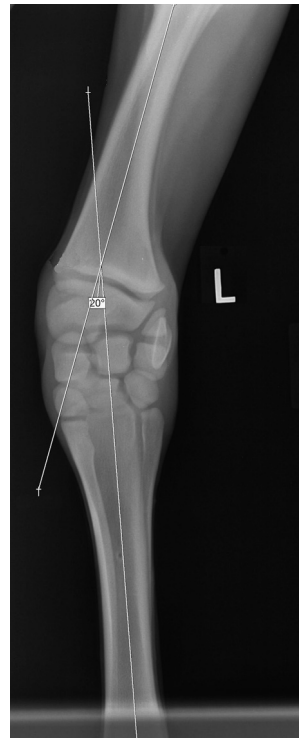

Fig. 5. Dorsopalmar radiographic view of a carpus with severe valgus deformity in a 17-day-old quarter horse colt. Lines are drawn parallel to the long axis of the radius and McIII. The point where these lines intersect is known as the pivot point. (*Courtesy of* Dr Ashlee Watts.)

palpated as the widest region in the distal radial metaphysis, is identified using a 20-gauge needle. For a carpus valgus deformity, a 4-cm to 6-cm longitudinal incision is made between the common and lateral digital extensor tendons starting just proximal to the physis. The incision is extended through to the periosteum. Using a curved scalpel blade (no. 12), a horizontal incision is made 1 cm to 2 cm proximal and parallel to the physis, at the distal end of the initial incision (parallel to the skin incision) forming an inverted T. The periosteal flaps are elevated with the aid of a periosteal elevator and then allowed to return to the normal position. It is important to transect the remnant of the ulna, or, if the ulna is ossified, it should be removed with the aid of rongeurs.[1,2] In foals with hind limb tarsus valgus the veterinarian should bear in mind that a fibular remnant may be present. The incision is closed routinely and the area is bandaged for 10 days to 14 days. The foal is kept in a large stall or small paddock until the deformity has been corrected.

Hemicircumferential periosteal transection and elevation have been reported to exert effects for up to 2 months, but the procedure can be repeated if further correction is needed.[1,2] There are no reports of overcorrection of the deformity. Early reports suggested approximately an 80% success rate[1,2,7]; however, more recent work indicates less favorable results.[11–13] A large retrospective study in Thoroughbred racehorses investigated racing performance after hemicircumferential periosteal transection and elevation.[11] A lower percentage of treated horses were able to start a race and had a lower starts percentile ranking number compared with half-siblings. Most of the foals

seemed to respond favorably to hemicircumferential periosteal transection and elevation based on external appearance of the limbs, but preexisting conditions, such as abnormal cuboidal bone formation from incomplete ossification or osteoarthritis secondary to abnormal loading of the limb before correction, may have influenced subsequent performance.[11]

ALDs are probably the most common orthopedic problem affecting Thoroughbred foals.[11,14] Early surgical intervention was previously recommended to take maximum advantage of the growth potential of the physis, to try to provide foals with excellent conformation, and to enhance sale value and possibly potential performance. Based on current knowledge, it seems likely that many foals with mild ALDs underwent unnecessary surgery. The reported success for correction of ALDs, particularly in the carpus, after hemicircumferential periosteal transection and elevation, has recently been challenged. Foals suffering from carpus valgus that underwent hemicircumferential periosteal transection and elevation were no more likely to improve compared with those managed with stall rest and corrective farriery.[12,13] Although the efficacy or need to perform hemicircumferential periosteal transection and elevation when treating foals with mild to moderate carpus valgus deviations is a matter of constant debate, the same cannot be said necessarily in other regions of the limb, such as the tarsus and fetlocks, without further investigation.

Tarsus valgus deformities frequently are unrecognized by both owners and veterinarians, possibly from lack of observation of foals from behind and the inherent offset position of the tarsus.[2,15,16] Early recognition and sometimes more aggressive surgical management of tarsal ALDs are critical to achieve satisfactory results. Although the distal tibial physis has a tremendous growth rate until 4 months of age, foals younger than 2 months of age responded more favorably to hemicircumferential periosteal transection and elevation than older foals. Transphyseal bridging (Taralyn M. McCarrel's article, "ALD: Growth Retardation," in this issue) was more effective than hemicircumferential periosteal transection and elevation, especially in foals older than 2 months of age.[15] This is a significant change from the previous perception that hemicircumferential periosteal transection and elevation alone were adequate when managing most tarsus valgus deformities in foals 4 months to 6 months of age. Early recognition of incomplete ossification of the tarsal bones is crucial, because the condition, if unrecognized, leads to collapse of the third or central tarsal bones, resulting in osteoarthritis.[15,16] Of 22 foals with incomplete ossification of the tarsal bones, 73% had tarsus valgus deformities. Only 32% of the foals were able to reach the intended use.[16]

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