Pros and cons of surgical repair techniques for management of angular limb deviation

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Conformational abnormalities in young horses are a significant problem in the equine industry and have a major impact on commercial sales, racing, and breeding operations. There is justifiable controversy regarding the ethics of the mass surgical intervention currently in place as well as the efficacy of some procedures. There is also ongoing controversy regarding the potential long term damage to the species and the clinical relevance of limb deviation relative to long term soundness. As veterinarians we have the ability to influence many decisions potentially altering the well being of the individual animal as well as the breed. Our prime objective is to achieve an individual with correct conformation that is skeletally sound for athletic purposes. There are a number of management, husbandry, and surgical techniques used to achieve this goal, however, some may have adverse effects and it is as important to know when not to intervene as when.

Angular limb deviation (ALD) refers to a deviation in axial alignment of the limbs when viewed on the frontal plane. Valgus deviation refers to a lateral deviation of the limb distal to a reference point and varus refers to a medial deviation. It is common knowledge that a certain amount of deviation is normal in young foals and no surgical intervention is necessary. Objective data is lacking regarding the dynamics involved in the development of acquired deformities, however, it is recognized that many foals change axial alignment during various stages of their development. An important point that is not commonly addressed is that many of these ALDs are transient and self-limiting during different stages of development and rapid surgical intervention is contraindicated. Serial evaluation and appropriate management changes for treatment of limb deviations is an integral component of management on most breeding operations.

Surgical intervention for correction of angular limb deformities is indicated if the deformity worsens during the first several months of age or if a moderate-to-severe deformity fails to improve within the first few weeks of age for ankles. Although most angular limb deformities in foals correct spontaneously, surgery is often performed in an attempt to take advantage of the rapid growth potential of the foal and to ensure correction of the deformity before this growth potential is lost. The surgical procedures in common use for correction of angular limb deformities are hemicircumferential periosteal transection with periosteal elevation (periosteal stripping) and transphyseal bridging. Periosteal stripping is performed on the relatively slow-developing (concave) side of the limb, whereas transphyseal bridging is performed to retard the faster-developing side of the limb. Transphyseal bridging may be accomplished with screws and wires, transphyseal staples, or a transphyseal single screw. Periosteal stripping and transphyseal bridging may be performed on the medial or lateral aspect of the limb at the distal radius, the distal metacarpus/metatarsus, or the distal tibia. A technique of iodine injection above the physis has been utilized instead of periosteal stripping, however will not be covered in this discussion other than to mention there is no data supporting its use.

The pros of periosteal elevation are that it is a minimally invasive single surgical procedure that has no evidence that over-correction occurs. If performed and managed appropriately post-operatively there should be no cosmetic blemish evident. Clinically it appears to be most effective if performed with other management changes such as corrective podiatry, or alterations in exercise and diet. The procedure must be performed during a rapid growth phase in order to be effective. On the negative side the procedure is of questionable efficacy and there is a body of work supporting the premise that there is no change in limb alignment associated with the procedure. If the procedure is effective, others question the ethics of the long term effects regarding the propagation of undesirable traits.

Techniques for transphyseal bridging vary in surgical time, rate of correction, cosmetics, surgical complications, and the cost of the implants. These differences often dictate a surgeons preference in a given situation relative to age of the animal, financial constraints, and ability of the client to perform appropriate post-operative care. All techniques share the advantages of retarding growth at the physis and therefore are effective so long as there is growth potential remaining. They also share good cosmetic outcome when performed at certain anatomical sites and maintained correctly. The common disadvantage shared by all is the requirement for a second surgery which may require general anesthesia, although some may be removed standing. Over-correction is a problem with all implants left too long and may have disastrous effects; the transphyseal screw appears to have a higher incidence of this likely because of its rapid rate of correction and over compression of the physis. Infection at the surgery site is also a shared complication by all and the incidence appears higher during the relatively warmer months of the year.
Transphyseal stapling requires the least surgery time requiring a single incision, hammering in the staple and counter-sinking, and closing the skin. Removal is comparable requiring a total of 3 to 5 minutes to perform. Cosmetics are generally good when performed on the medial aspect of the distal radius for carpal valgus and I still prefer the technique in foals less than 3 to 4 months of age. There is a high probability of a blemish when used on the distal lateral radius, or distal metacarpus or distal tibia. In foals 2 to 3 weeks of age that have severe carpal valgus and are dysmature the staple may pull out of the bone and not hold, therefore if no correction is seen in 3 weeks radiographs should be taken to assure correct positioning of the implant. Rate of correction is comparable to screws and wires and definitely slower than transphyseal screw. Intra-operative complications include placement of the staple too proximal or distal; this may be avoided with intra-operative radiographic monitoring although proper use of landmarks make this unnecessary. Comlications of staple removal include difficulty in locating the implant especially if originally placed by another surgeon. Breaking one of the arms of the staple may occur if the staple is not elevated evenly upon removal. Cost of transphyseal staples ($75 - $100) is considerably higher than that of the other implants if having to purchase new. A second general anesthetic is required for removal.

Screws and wires have been popular since the 1980s for use in correction for ALD. They reportedly had more appealing cosmetics than staples and theoretically produced more rapid correction because of the immediate compression afforded by tightening the wire. I have not found either of these statements to be completely true in that staples appear to correct as quickly as screws and wires and cosmetics largely depend on the site operated. All implants have the possibility of producing a characteristic blemish at each location. In general, screws and wires have a more favorable cosmetic outcome on the lateral radius and ankle when compared to staples, but still have the chance of excessive soft tissue and bone reaction at the surgery site especially after implant removal. Cost of materials for the surgery is approximately one half that of staples not counting instrumentation; the cost compared to transphyseal screw is approximately double. A disadvantage of the screw and wire technique includes duration of surgery which is more than double the other techniques. Wire breakage during or immediately after surgery or having the wire slip from the screw head are all possibilities that may result in failure of the implant to achieve correction. It is a preferred technique for carpal deviations in late weanlings and yearlings in which slower correction is desired or physeal dysplasia is evident and over correction is a concern. These implants may be removed standing if so desired. Transphyseal screw placement has been in use since the late 1990s and is the most commonly performed bridging technique for treatment of ALD. The major advantages of the technique include short surgery time for placement and removal, speed of correction of the deviation, lower cost compared to other implants, and mostly, ideal cosmetics. All of these advantages are negated if any complications occur in surgery such as misdirection of the screw, inappropriate screw length (too long or short), inability to locate the screw head for removal due to callus overgrowth, and breakage of the screw upon removal. Wound infection is a concern as is bandage complications such as pressure or friction decubital ulcers over bony prominences, premature removal of bandages, allowing bandages to get wet or not changing enough. A major problem with distal metacarpal screws is the lack of soft tissue covering the implant resulting pressure necrosis with a firm bandage. This may be avoided by use of a donut over the screw head of using a small amount of gauze placed as a spacer caudal to the screw head. These implants may be removed with the patient standing or recumbent depending on the patient and surgery site.

Transphyseal stapling for carpal valgus deformity is performed on the medial aspect of the distal radius. Before the incision is made, the skin over the distal medial radius is rolled cranially 2 cm, and the physis is identified with a needle. With a #15 scalpel blade, a 3 cm proximal-to-distal incision centered over the physis is made through the skin and subcutaneous tissues to the level of the periosteum. The incision should be place 1.5 to 2 cm caudal to the medial prominence of the radial physis; with the staple in the position, a blemish is less likely to occur. A transphyseal staple is centered on the incision, with one staple arm in the metaphysis and the other in the epiphysis, and is driven to the level of the skin with a mallet. Final seating of a staple is performed with a counterpunch driven with a mallet. The skin is repositioned caudally to its correct location and sutured with synthetic absorbable suture material in a horizontal mattress pattern. A pressure bandage consisting of 4x4 gauze sponges and elastic tape is then applied. The foal should be confined to a stall for 1 to 2 weeks and should receive perioperative antimicrobial therapy and tetanus prophylaxis. The bandage should be removed 1 to 2 weeks after surgery.

It is imperative that the staple be removed once the limb has straightened. After the skin is rolled cranially the staple is located with a needle. The skin and subcutaneous tissues are sharply incised to the level of the staple by use of a #15 scalpel. The scalpel is used to dissect over the cranial and caudal edges of the staple. An elevator is placed between the bone and the body of the staple, which is then levered free from the bone. Closure, bandaging, and aftercare are similar to those after staple placement.

Carpal valgus deformities of less than 10 degrees in foals younger than 4 to 5 months of age benefit from
periosteal stripping. Carpal varus deformities respond less favorably to this technique and may require transphyseal bridging at a later date. Transphyseal bridging of carpal angular limb deformities may be performed from birth until 14 to 16 months of age. Angular deformities of the fetlocks require intervention by 1 to 2 months of age to achieve correction with periosteal stripping and by 3 to 4 months to achieve correction with transphyseal bridging. Tarsal deformities should be addressed on a similar time frame as carpal deformities.

The rate of response to surgery depends on the age of the foal, which surgery was used, and whether or not the foal undergoes a rapid growth phase soon after surgery. After periosteal stripping, a response may be seen as early as a few days later if the procedure is performed during a growth phase. It more commonly takes several weeks to benefit from the surgery.

SURGICAL TECHNIQUES
Surgical landmarks for periosteal stripping of the distal lateral radius are the distal radial physis, the common digital extensor tendon, and the rudimentary fibrous ulna. The modified procedure is accomplished thorough a stab incision made with a #15 scalpel blade positioned approximately 1.5 to 2.0 cm proximal to the distal radial physis between the common and the lateral digital extensor tendons. The incision should extend through the skin and subcutaneous tissues to the level of the periosteum. The scalpel blade is advanced proximally 3.0 to 4.0 cm, tunneling beneath the skin to facilitate the dissection. At the proximal extent of the dissection, the periosteum is incised to the level of bone by applying pressure to the scalpel which is continued distally to the level of the original skin incision. The horizontal component of the inverted T is made in a similar tunneling fashion by first coursing cranially beneath the common digital extensor tendon with the scalpel, then incising the periosteum and retracing the scalpel toward the skin incision. The final part of the horizontal component is made by tunneling caudally deep to the lateral digital extensor tendon and caudally to the rudimentary fibrous ulna.

The scalpel is used to sharply incise the periosteum and ulna, and the periosteum is transected to the level of the skin incision. A periosteal elevator is introduced through the skin incision at the junction of the vertical and horizontal dissection planes through the periosteal incision. The cranial and caudal triangular periosteal sections are elevated from the underlying bone in a routine fashion. Any blood that accumulates beneath the skin is expressed through the incision with gauze, and a pressure bandage consisting of a 4 x 4 gauze sponges and elastic tape is applied over the incision. The original stab incision is not closed. The foal is allowed paddock or pasture turnout. Postoperative antimicrobial therapy is administered at the discretion of the surgeon based on the environment. The bandage is removed 5 to 7 days after surgery. Tetanus prophylaxis is administered if indicated.

SCREW AND WIRE TECHNIQUE
Screws and wires have been utilized for transphyseal bridging since the 1970’s. Self tapping screws are placed following drilling an appropriate hole 2 cm above and 1.5 cm below the physis. A piece of 18 gauge stainless steel wire is tunneled from the distal screw proximally one arm at a time forming a loop around the distal screw. After placing a “figure 8” configuration, the wire is twisted above the top screw and cut. The screw heads are tightened which will provide more tension on the wires. Post operative management is the same as for staples.

The duration of time required for correction of an angular deformity after periosteal stripping or transphyseal bridging depends on the age at the time of surgery, the rate of growth, and the degree of deformity present. If surgery is performed to correspond with a rapid growth phase, improvement of the deformity may be seen a few days to a week after surgery. If no improvement has occurred within 3 to 4 weeks after periosteal stripping, it is unlikely that this first procedure will correct the deformity, and that procedure may be repeated or a transphyseal bridging should be performed.

SINGLE SCREW TECHNIQUE FOR TRANPHYSEAL BRIDGING
The most recent advancement in transphyseal bridging in equine surgery is the use of a single screw coursing from the metaphysis to epiphysis. The initial report described the use of a lag screw technique to correct tarsal valgus deviation with a screw coursing from the epiphysis to metaphysis of the medial malleolus of the tibia. The lag screw principle was abandoned because of excessive tension placed on the screw with limb growth resulting in difficult removal or potential screw breakage. Presently, a position screw technique is utilized for all locations.

The following description is for the medial and lateral placement for transphyseal screw placement of the distal radius or distal metacarpus/metatarsus. The landmark for the physical growth plate is a protuberance along the caudal or palmar medial or lateral aspect of the bone at the metaphysis – epiphysial junction.
The growth plate may also be identified with a needle with or without radiographic control. A stab incision is made with a #15 scalpel 1.5-cm proximal to the protuberance (physis) caudal or palmar to the medial or lateral mid-point of the metaphysis. A 4.5-mm drill bit is positioned perpendicular to the long axis of the bone within a guide and drilled to a depth of 4 to 5 mm to create a shelf for the 3.2-mm drill. The 3.2-mm drill in a guide is inserted at the shelf and directed distally at approximately a 20 degree angle and slightly cranial. Care must be exercised to avoid trauma to the skin with the drill. Resistance is encountered when engaging the physis; once this region has been passed, the drill is advanced approximately 70% of the length of the epiphysis. An appropriate length 4.5-mm self-tapping cortical screw is inserted and tightened so approximately 50% of the width of the head is palpable above the surface of the bone (approximately 48-mm for ankles and 58-mm for knees). Depth may be assessed using a depth gauge or a piece of wire against a ruler. Upon final tightening, the screw should be backed out and tightened several times to seat and prevent over tightening to facilitate removal. Accurate placement is confirmed with intra-operative radiographs. A simple interrupted suture is optionally used to close the incision and an elasticon bandage is applied to the distal radius and padded combine bandage is used on ankles.

Transphyseal bridging of ankles in foals less than 2-months of age may be performed with 3.5-mm self-tapping screws. The procedure is the same other than creating the shelf with a 3.5-mm drill and using the 2.7-mm drill for the screw hole.

Transphyseal screw placement of the distal tibia may be performed in dorsal or lateral recumbency. Following preparation, a stab incision is made through the skin and subcutaneous tissue to the distal tip of the medial malleolus. A 3.2-mm drill in a guide is inserted and drilled proximally through the epiphysis, physis, and metaphysis parallel to the long axis of the limb. A 4.5-mm self-tapping cortical screw is inserted and tightened. Average length of the screw is 60 to 70-mm. Radiographic control is used to confirm correct placement. It is not necessary to close the incision. An elasticon bandage is applied. At the appropriate time, screw removal may be performed standing with sedation and local anesthesia or recumbent under general anesthesia. A stab incision is made at the proximal extent of the screw head. The screw driver is seated and screw is removed. The incision is left open and a bandage is applied.

REFERENCES