INTRODUCTION

Ankylosis can be defined as abnormal adhesion or joining of the bones within a diarthrodal joint. It usually occurs following significant disease or injury to the joint surfaces and, in general, is a slow process in which the patient subjected to considerable local inflammation and pain. However, if this process results in stability of the joint, the inflammation subsides leaving a relatively pain free union. The term arthrodesis describes a surgical procedure that, in most cases, removes the articular cartilage and stabilizes the joint using implants resulting in a suitable environment for ankylosis of the joint to occur. Facilitated ankylosis describes a surgical procedure that, in some way, removes or destroys the articular cartilage without application of stabilizing implants. However, in the equine scientific literature, these three terms are often used interchangeably to describe the many different techniques utilized to induce fusion of a joint.

Arthrodesis and/or facilitated ankylosis procedures are becoming more and more common in today’s equine practice. Newer, more innovative techniques and advancement in available implants have improved the long term prognosis for many indications relating to both high and low motion joints. Surgical ankylosis of any high motion joint is considered a salvage procedure ideally resulting in breeding or pasture sound animals. In contrast, surgical ankylosis of a low motion joint is often a more elective procedure, aimed to eliminate lameness in an athletic horse. In either case, the cause of the joint disease necessitating ankylosis significantly effects prognosis as does the chronicity of the disease process. In other words, arthrodesis for treatment of osteoarthritis (OA) has a better prognosis, in general, than one performed for treatment of an intra-articular fracture and the sooner the procedure is performed in the course of disease, the better. A myriad of potential complications exist following surgical ankyloses procedures ranging from local tissue irritation to contralateral limb laminitis. The following information briefly describes the indications, techniques and prognosis for joints of the equine distal limb currently subjected to surgical arthrodesis and/or ankylosis procedures.

LOW MOTION JOINTS

Distal Hock joints (Tarsometatarsal Joint, Distal Intertarsal joint, and Proximal Intertarsal Joint)

The primary indication for facilitated ankyloses/arthrodesis of the distal hock joints is related to OA (bone spavin). Other indications include fractures to the small tarsal bones and luxation. Many different facilitated ankylosis techniques have been described for the treatment of distal tarsal OA including surgical drilling, chemical injection, laser-facilitated and plate application. As the name implies, surgical drilling involves using a 3.2 or 4.5mm bit to drill three tracts across the joint surface(s) exposing subchondral bone thus inducing ankylosis. In clinical studies using this technique, ~70% of horses were considered to have long-term improvement . Chemical injection involves introduction of a caustic agent into the joint that destroys the articular cartilage encouraging ankylosis of the joint. A contrast
arthrogram is recommended prior to injection to determine if any communication exists between the individual hock joints. Any communication of the distal two joints with the proximal intertarsal or tarsocural joint should dissuade this technique. Ethyl alcohol (EA) and monoiodoacetate (MIA) have both been successfully used to fuse the DIT and TMT joint of horses. However, many horses exhibit extreme discomfort 12-24 hours following MIA injection which has precluded its widespread use. EA works through non-selective protein denaturation and cell dehydration. It also destroys the intra-articular sensory innervation therefore significantly less post-injection pain is recognized. A clinical study using EA for treatment of OA reports 11/21 horses improved in lameness 6-9 months following injection. Laser facilitated distal tarsal arthrodesis can be accomplished by applying laser energy to the joint(s) using a diode or a neodymium:yttrium aluminum garnet (ND:YAG) laser. The laser energy superheats and vaporizes the synovial fluid causing chondrocyte death promoting at least partial ankylosis. Although studies evaluating laser facilitated arthrodesis of the distal hock joints in arthritic joints are lacking, experimental studies in sound horses resulted in partial ankylosis 5-12 months postoperatively. Plate application can be used for treatment of distal tarsal OA but it is generally reserved for arthrodesis necessitated by fractures to the small tarsal bones or luxation +/- fracture(s) of one of the three distal tarsal joints. These indications require added stabilization relative to simple OA and are often best treated by application of a 12-14 hole compression plate to the plantarolateral aspect of the calcaneus and proximal metatarsus. Prognosis for this type of arthrodesis procedure is very much dependent on the configuration of the fracture(s) and the amount of soft tissue trauma.

**Proximal Interphalangeal Joint (Pastern)**

Indications for arthrodesis of the proximal interphalangeal joint include severe OA, luxation, osteochondrosis (subchondral cystic lesions), and fractures of the middle and/or proximal phalanx. Many techniques are described including placing 2-3 cortical bone screws transarticular in lag fashion, a single dorsal plate w/ two transarticular screws, and two dorsal plates. The type of fixation needed depends on the age of the horse and clinical indication. The single plate technique provides superior joint stability post operatively when compared to the 2-3 screw technique thus this technique is recommended for treatment of most non-fracture indications. Application of two dorsal plates for proximal interphalangeal arthrodesis is generally reserved for treatment of middle phalanx fractures. Cartilage debridement is routinely performed thru an open dorsal approach but recently, minimally invasive cartilage destruction techniques followed by transarticular screws placed thru stab incisions have been described. In one report, the use laser facilitated cartilage destruction and screw fixation induced arthrodesis in 4 and soundness in 5/6 horses. In contrast, EA injection alone and in combination with screw fixation failed to reliably result in fusion experimentally in 6 horses at 10 months. Long term prognosis using the single dorsal plate w/ two transarticular screws is favorable. One study evaluating 53 horses reports 87% returned to intended use (81% forelimbs, 95% hind limbs).

**Carpometacarpal Joint**

Indications for arthrodesis of the carpometacarpal joint (CMJ) are OA and luxation. Although the CMJ is similar anatomically to the distal hock joints, OA of the former does not respond as favorable to intra-articular and other medical therapies as the latter. In fact, horses suffering from CMJ OA treated with conservative non-surgical management have a poor prognosis for return to soundness and an unfavorable prognosis for life. The reasons for this are unclear but since significant OA changes are seldom seen in the intercarpal joint (ICJ) concurrently, the communication of the CMJ with this high motion joint does not appear to influence the condition. However, because of this communication, the use of chemicals, such as ethyl alcohol, to promote bone ankylosis is not possible without risk of severe ICJ damage. Surgical drilling can achieve bony ankyloses and has been shown to be successful in the
treatment of CMJ OA resulting in soundness within 6 months following surgery. CMJ luxation requires internal fixation with one or two dorsally applied compression plates or T-plate, depending on the size of the patient. Often times, especially in adults, these injuries involve additional fractures to the articulating bone and have significant soft tissue damage making the prognosis unfavorable.

HIGH MOTION JOINTS

Distal Interphalangeal joint (Coffin)

Indications for arthrodesis of the distal interphalangeal joint (DIJ) are severe OA and injuries to the foot leading to joint instability. Arthrodesis of this joint is rarely performed. The orientation of this joint within the confines of the hoof capsule makes cartilage debridement and implant placement difficult. Two techniques for arthrodesis of the DIJ are described. The first utilizes both dorsal and palmar arthroscopic approaches thru which 80% of the articular cartilage is debrided with a motorized burr. Three 5.5 mm cortical bone screw are then placed in lag fashion across the joint in a dorsal to palmar orientation thru holes created in the dorsal hoof wall. These holes are then filled with antibiotic impregnated polymethyl acrylate. The second technique utilizes two approaches. An extensive dorsal approach is used and the DIJ is subluxated to allow open articular cartilage debridement. A palmar incision is made into the digital sheath and a deep digital flexor tenotomy is performed. Stab incisions are made thru the insertion of the straight sesamoidean ligament to allow the placement of three 5.5 mm cortical screws extending from the proximal palmar/plantar rim of the middle phalanx across the joint into the distal phalanx in lag fashion. With either technique, cancellous bone graft or bone graft substitute can be utilized and, following fixation, the limb is maintained in a half limb cast for 1-3 months. Both techniques have resulted in successful DIJ fusion but no reports comparing the two techniques are published.

Metacarpo/tarsophalangeal joint (Fetlock)

Indications for arthrodesis of the fetlock joint include severe OA, comminuted proximal phalanx fractures, and severe flexural deformities but suspensory apparatus disruption, especially in racing horses (breakdown injuries), is the most common indication. The standard technique involves application of a 10-14 hole 4.5 mm or 5.5 mm compression plate along the dorsal surface of the joint with additional transarticular screws placed in lag fashion. Biomechanically, the palmar/plantar aspect of the fetlock joint is under tension. Plate application to the dorsal surface is not optimal and without palmar/plantar support, cyclic failure of the plate is likely. To prevent this, a palmar/plantar tension band effect must be established. If the proximal sesamoid bones and distal sesamoidean ligaments (DSLs) are intact, appropriate support can be obtained by placing two 5.5 mm screws in lag fashion thru the metacarpal/metatarsal bone into the proximal sesamoid bones fixing them in position. In cases of biaxial proximal sesamoid fracture or when the DSLs are disrupted, two cerclage wires placed in a figure-of-eight pattern across the palmar/plantar aspect of the joint is required. Following surgery, the limb is maintained in a half limb cast for 4-6 weeks. Prognosis for survival following plate fixation technique ranges from 25-75% depending on the exact technique employed and indication for arthrodesis. Breakdown injuries can be complicated by significant injury to adjacent soft tissue structures including the vascular supply to the digit. Prognosis is better for horses undergoing arthrodesis for OA rather than traumatic injuries. In certain indications, facilitated ankyloses of the fetlock can be induced by open cartilage debridement, packing the joint with cancellous bone graft and stabilization using transfixation pin casting.
Radiocarpal and Intercarpal joints (Carpus)

Partial carpal arthrodesis refers to surgical ankylosis of one of the proximal two carpal joints whereas pancharpal arthrodesis describes fusion of all three carpal joints lending the carpus completely immobile. Partial carpal arthrodesis is preferred over pancharpal arthrodesis when possible so that at least some motion at the carpus is preserved. Indications for radiocarpal joint partial carpal arthrodesis include severe OA and luxation. Indications for ICJ partial carpal arthrodesis include severe OA, luxation and comminuted fractures of the distal row of carpal bones. Indications for pancharpal arthrodesis are severe OA of all of the carpal joints, multiple carpal bone fractures and severe angular limb deformity originating within the carpus. Most commonly, two compression plates are applied dorsally following open cartilage debridement and application of cancellous bone graft. Following surgery, the limb is supported in a full limb cast +/- transfixation pins placed in the distal radius. This cast is generally maintained for 2-4 weeks when it is replaced with a carpal sleeve cast for an additional 4-6 weeks. Prognosis for survival and comfortable weight bearing is reported to be 67%.15

Scapulohumoral joint (Shoulder)

Arthrodesis of the shoulder joint is possible in miniature and very small horses/ponies. Indications are severe, debilitating osteoarthritis or luxation/subluxation. The technique involves application of a long compression plate to the cranial aspect of the scapula and humerus after ostectomy and/or contouring of the intermediate tubercle. Only a handful of scapulohumeral arthrodeses have been reported in the literature but it is described as a successful technique.16

SUMMARY

Arthrodesis and/or facilitated ankyloses procedures can significantly improve the comfort and/or performance of horses affected with debilitating joint disease or injury. For most equine joints, multiple different techniques are described to optimize ankyloses and the exact injury or disease process must be carefully evaluated in order to determine the appropriate course of action. In general, joints affected with OA are much better candidates than those affected by fracture(s) and/or significant soft tissue damage. Although the prognoses for the different joints and techniques are variable, expectations for surgical ankyloses of high motion joints should be for breeding/pasture sound animals whereas fusion of low motion joints may yield athletically sound horses.
REFERENCES

5. Hague BA, G