Arthrodesis Techniques in Horses
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Osteoarthritis is a common problem that occurs in all types of horses secondary to joint injury, osteochondrosis, or infection or primarily from the wear and tear of repetitive use. It can cause progressive degeneration of the joint to a point where normal joint function is no longer possible. Affected horses develop chronic lameness that cannot be successfully treated with anti-inflammatory medications or surgical procedures aimed at restoring joint function. When these treatments fail to return the animal to athletic performance or comfortable use of the limb, arthrodesis is a final option for some joints. In horses with osteoarthritis of low-motion joints, such as the proximal interphalangeal (PIP) joint or the distal tarsal joints, arthrodesis is performed with the goal of returning them to athletic performance. In high-motion joints, arthrodesis is performed to improve the horse’s use of the limb, with the goal of giving the horse long-term comfort rather than returning the horse to performance. Horses with fusion of high-motion joints have some degree of lameness (comfortable cripple) but support enough weight on the limb to avoid complications from overloading the contralateral limb.

Arthrodesis refers to the surgical fusion of a joint, resulting in bony ankylosis. Ankylosis of some joints can occur naturally in horses; however, in high-motion joints, bony bridging of the articular surface is rare. As joint disease becomes advanced, articular cartilage degeneration results in bone-on-bone contact and severe lameness. Ankylosis removes the source of pain in many cases; however, without surgical intervention, the process occurs over a period of several years and may never result in complete bony union and pain-free ambulation in some joints. There are currently accepted
methods for arthrodesis of several joints in the horse; however, not all joints are amenable to arthrodesis. This article describes arthrodesis procedures commonly used in horses.

Successful arthrodesis requires debridement of the articular cartilage through the calcified cartilage layer, exposing the subchondral bone; alignment of the joint into a weight-bearing position; and stabilization [1]. The methods by which these steps are accomplished are variable, depending on the individual joint. In some joints, fusion occurs after ablation of the articular cartilage; however, in most joints, internal fixation is used to stabilize the joint.

Case selection is an important aspect of performing arthrodesis procedures in horses. Some horses can live comfortable long lives with osteoarthritis in one or several joints without requiring fusion. In low-motion joints, horses with chronic lameness that is not responsive to management with anti-inflammatory medications are candidates for arthrodesis. In high-motion joints, the criteria become more complicated. The indication for arthrodesis must be based on the comfort level of the horse on the limb with the affected joint. Based on our clinical experience, horses that are supporting less than 50% of their normal weight-bearing force on the leg at a walk are candidates for an arthrodesis procedure because they are at risk for developing overload laminitis in the foot of the contralateral limb. Foals with this degree of lameness can develop angular limb deformities as the result of the abnormal forces created on the limb when the foal centers its leg to support most of its weight on one limb.

**Arthrodesis of low-motion joints**

*Proximal interphalangeal joint*

Arthrodesis of the PIP joint is performed in horses with chronic osteoarthritis that is no longer responsive to anti-inflammatory medications, osteochondrosis, articular fractures, unstable joint injuries, or septic arthritis. Unlike arthrodesis of high-motion joints, arthrodesis of the PIP joint is usually performed with the goal of returning the horse to athletic performance. Careers requiring repetitive stopping and turning, such as that occurring in western event horses, can predispose horses to osteoarthritis of this joint. These same horses are exposed to acute overload forces when performing at high speeds that can cause fractures or destabilizing injury to the supporting soft tissue structures of this joint. In addition to performance horses, any horse that suffers trauma to the pastern region can have severe damage to this joint. The pastern is frequently injured when horses get a foot caught in a fence or under a panel. Also, any horse running in a field at high speed can injure the pastern joint.

The PIP joint has been arthrodesed using a wide variety of techniques [2–13]. The first procedure that was routinely used to arthrodesed this joint
in horses was three parallel 4.5-mm cortical bone screws placed across the joint in lag fashion [13]. This procedure was successful in a large number of horses; however, these horses were frequently maintained in a half-limb cast for 6 weeks because of postoperative discomfort. Despite the relatively recent publication of retrospective studies reporting the successful use of two cortical bone screws placed in lag fashion across the joint for arthrodesis of the PIP joint [6], most surgeons have moved toward techniques that have increased the stability of the fixation used to stabilize the joint. Stability was initially increased by using 5.5-mm cortical bone screws and since has evolved to the combination of a dorsal plate in addition to lag screws [2,14]. Greater stability has increased the horse’s postoperative comfort, minimized patient morbidity, and allowed the horse to be taken out of a cast at 2 weeks and released from the hospital, decreasing the expense of treatment. Application of a dorsal dynamic compression plate (DCP) with three transarticular lag screws seems to be the most stable technique currently used in cases of osteoarthritis and articular fracture [2,14].

The patient is placed in lateral recumbency with the affected limb positioned uppermost. The configuration of some second phalanx fractures may dictate positioning the horse with the affected leg down. The PIP joint is approached through an inverted “T”-shaped incision centered on dorsal midline, with the horizontal component created 1 cm proximal and parallel to the coronary band. The subcutaneous tissue is dissected free of the extensor tendon and remains with the skin flaps as they are reflected. The extensor tendon and joint capsule are transected in an inverted “V” to open the PIP joint. The base of the V-shaped incision is positioned at the level of the joint to allow access to the collateral ligaments laterally and medially. The PIP joint is distracted using Kelly hemostatic forceps or an osteotome, and the collateral ligaments are transected. The joint is then luxated dorsally, the articular cartilage is removed, and the subchondral bone of the proximal and middle phalanges is foraged. The joint is reduced, and a four-hole narrow DCP is contoured to the dorsal surface of the first phalanx and the proximal portion of the second phalanx. A 5.5-mm cortical bone screw is inserted through the distal hole of the plate into the second phalanx. This screw should be positioned to allow room for the next screw proximal in the plate to be placed transarticularly into the proximal aspect of the second phalanx. This 4.5-mm cortical bone screw is angled to cross the joint but also angled to avoid the distal screw in the plate. The plate is attached to the proximal phalanx in load fashion, using a 4.5-mm cortical bone screw in one of the two proximal holes. With the joint in anatomic alignment, 5.5-mm cortical bone screws are placed in lag fashion on the lateral and medial sides of the plate. The screws should cross the joint palmar or plantar surface to the center of the articular surface. Intraoperative radiographic control is necessary to avoid penetrating the palmar or plantar cortex of the second phalanx close to the navicular bone (Fig. 1). The proximal screw is placed in
the plate routinely, usually through a stab incision through the extensor tendon.

The extensor tendon is reapposed with simple interrupted sutures using monofilament absorbable suture. The skin is closed routinely. The incision is covered with a sterile nonadherent dressing, and a fiberglass half-limb cast is applied. The cast is maintained for 2 weeks, when the sutures are removed and the horse is placed in a heavy support bandage. The support bandage is maintained for an additional 2 weeks. The horse is stall rested for 90 days; at that time, radiographs are taken to evaluate fusion of the joint. If there is bone bridging the joint, the horse may then be turned out in a small paddock (30 ft × 30 ft) for an additional 3 to 6 months. Generally, 6 to 12 months is required after surgery before horses return to complete soundness.

Reported success rates of the procedure for horses with osteoarthritis of the PIP joint range from 50% to 85%; however, technical failures have been associated with chronic lameness in some horses [2,3,5,9,11]. Technical failures include placing the plate too far distally, resulting in inflammation and osteoarthritis of the distal interphalangeal (DIP) joint, and having the transarticular lag screws exit the second phalanx too far distally, resulting in inflammation in the area of the navicular bone. Many horses have successfully resumed athletic careers after fusion of the PIP joint. The success rate seems to be higher in horses that have had one rear pastern joint fused [2,6]. In our experience, the most common reason for horses to develop lameness after successful pastern fusion in the forelimbs is the development of osteoarthritis in the DIP joint. Case selection is important to avoid horses that may already have arthritis started in the DIP joint so as to improve the long-term prognosis for this procedure.
Open PIP joint injuries are fairly common in horses secondary to wounds that occur in the pastern region. Horses frequently catch a foot under a panel or fence, suffering trauma and lacerations that can penetrate the joint and injure the collateral ligaments. Because the joint is open, using internal fixation increases the risk of persistent infection occurring because of the addition of foreign material. If the joint can be placed in a weight-bearing position, the PIP joint can be fused. The joint can be opened and articular cartilage debrided similar to the approach described previously, or some of the articular cartilage can be removed by passing a 4.5-mm drill bit across the pastern joint through two or three vertical dorsal arthrotomy incisions (Fig. 2). After cartilage removal, the joint is packed with autogenous cancellous bone graft and antibiotic-impregnated polymethylmethacrylate (PMMA) implants and the limb is stabilized with a half-limb cast [15]. A transfixation pin cast may be used depending on the instability of the joint and the degree of discomfort of the horse. The horse is usually maintained in a cast for 10 to 12 weeks. Although these horses can have more complications attributable to infection and decreased comfort on the limb in the postoperative period, those horses that fuse can return to soundness and their intended use.

Fig. 2. The articular cartilage of the PIP is debrided by passing a drill bit across the joint in a dorsal-to-palmar or plantar direction, and the joint is packed with autogenous cancellous bone graft and antibiotic-impregnated PMMA.
Arthrodesis of the distal tarsal joints

Osteoarthritis of the distal intertarsal (DIT) and tarsometatarsal (TMT) joints (bone spavin) is a common cause of lameness in equine athletes. Chronic repetitive compression, torsion, and shear strains frequently cause osteoarthritis; however, it can also occur secondary to osteochondrosis (juvenile spavin) or articular fracture. Distal tarsal osteoarthritis is common in horses performing in events that increase torsional and shear forces on the distal tarsal joints, such as those that run hard at a gallop, jump obstacles, or race at a trot or pace as well as in western performance horses used for reining, cutting, roping, and barrel racing. Osteoarthritis of the DIT and TMT joints can be managed successfully with anti-inflammatory medications; however, the results of medical management can be disappointing, and lameness may persist in 25% to 50% of the cases [16].

In some horses, the cartilage degeneration associated with osteoarthritis progresses to bony fusion of the DIT and TMT joints. These horses frequently become sound; however, degeneration only progresses to fusion of the distal tarsal joints in both hind limbs in a small number of horses. Therefore, a number of techniques to promote fusion of these joints have been developed. The diversity of techniques reflects the lack of a single superior method of arthrodesis. Recently, successful outcomes have been reported after fusion procedures using surgical drilling (SD), sodium monoiodoacetate (MIA) injection, and laser surgery of the DIT and TMT joints [17–24].

A recent retrospective study evaluating the use of SD to treat osteoarthritis of the DIT and TMT joints reported that 59% of the horses returned to their previous level of athletic performance without signs of lameness [19]. SD removes focal areas of articular cartilage and promotes osseous union between the bones [22]. The cunean tendon is identified by palpation, and a 30-mm vertical skin incision is made over the distal two tarsal joints on the medial side of the tarsus distal to the cunean tendon. A 0.9-mm × 25-mm (20-gauge, 1-inch) needle is then inserted into the DIT and TMT joints. The position of the needle within the joint is confirmed with fluoroscopy or intraoperative radiographs. A 3.2-mm drill bit is passed into each joint, and placement of the drill is again confirmed with fluoroscopy. A 4.5-mm drill bit is then used to create three drill holes across each joint in a diverging pattern. Each tract is drilled to a depth between 2 and 3 cm; drill positioning in the joint is confirmed with fluoroscopy. Subcutaneous tissue and skin are closed routinely. The distal tarsus is placed in a bandage to protect the surgical incision.

Intra-articular injections of MIA, a chemical compound that causes cartilage death and stimulates fusion, have also been used to fuse the DIT and TMT joints [23]. Study results have shown that 40% to 90% of the animals had successful outcomes after MIA injection and that 97% of the horses had bone bridging the joints at 12 months [17,18,23,24]. Many horses
exhibit discomfort for 12 to 24 hours after MIA injection, however. Injections of MIA can be performed under general anesthesia or in the standing sedated horse. A 0.7-mm × 25-mm (22-gauge, 1-inch) needle is inserted into the TMT joint proximal to the fourth metatarsal bone and directed distally and medially at an angle of 45° [25]. A 0.7-mm × 25-mm (22-gauge, 1-inch) needle is inserted into the DIT joint at the junction of the fused first or second, third, and central tarsal bones on the medial side of the tarsus, distal to the cunean tendon [25]. Confirmation of needle placement is made by retrieval of synovial fluid or via radiography. Each joint is injected with 100 mg MIA diluted in 0.9% sodium chloride (2 mL) that has been aspirated through a 0.22-μm filter (Millex-GV; Millipore Corporation, Bedford, Massachusetts) to eliminate bacteria [17].

Laser-facilitated ankylosis has also been performed using a neodymium: yttrium aluminum garnet (Nd:YAG) or diode laser to destroy articular cartilage by superheating and vaporizing synovial fluid [20,25]. It has been proposed that temperatures greater than 62°C result in chondrocyte death as well as a collagen shift in the intertarsal ligaments and joint capsule [20,21,26]. A 1.1-mm × 40-mm (18-gauge, 1-inch) needle is placed on the medial and lateral sides of each DIT and TMT joint. Needle position is confirmed with radiographs or fluoroscopy. The lateral needles serve as vents for plume evacuation during the application of laser energy to the joints. A 5-mm skin incision is made over each joint in the location of the needle on the medial side of the tarsus using a number 11 scalpel blade. A 1.3-mm × 90-mm (16-gauge, 3-inch) stainless-steel needle is placed in the DIT and TMT joints through the skin incisions. A 600-μm contact laser fiber (600-μm Bare Fiber Assy, Flat Tip; BioLtec, East Longmeadow, Massachusetts) is inserted through the needle; the laser fiber and needle are advanced across the joint as the laser (AccuVet 50D, 980-nm Diode Surgical Laser; Lumenis, Santa Clara, California) is activated. Approximately 1200 J of laser energy is applied to each joint. Needles are cooled by irrigation with chilled 0.9% sodium chloride during the procedure. Skin incisions are closed with 2-0 polypropylene suture in a simple interrupted pattern. The distal tarsus is placed in a sterile adhesive bandage. Clinical articles on laser-facilitated ankylosis techniques have reported an increased percentage of sound horses, minimal postoperative pain, and decreased convalescent time compared with other methods of arthrodesis [20,21,26].

Assessment of these three arthrodesis techniques for distal tarsal joint arthrodesis have been evaluated by the authors by comparing the degree of lameness after treatment as well as by the amount of fusion of the distal two tarsal joints [27]. Twelve horses were evaluated and were split into two groups. Group 1 (n = 6) had laser surgery performed on the DIT and TMT joints of one tarsus and MIA injection into the contralateral DIT and TMT joints; these horses were evaluated for 6 months. Group 2 (n = 6) had laser surgery performed on the DIT and TMT joints of one tarsus and SD of the contralateral DIT and TMT joints; these horses were evaluated for 12
months. Postoperative comfort, lameness, radiographs, microradiographs, and histologic findings were compared between groups and between the joints within groups.

Laser surgery produced the least postoperative morbidity. In group 1, horses were less lame in four laser surgery–treated limbs and two MIA-treated limbs at 6 months. In group 2, horses were less lame in five laser surgery–treated limbs and one SD-treated limb at 6 and 12 months. Microradiographs revealed that 11 of 12 MIA-treated joints and 2 of 12 laser surgery–treated joints had bone bridging the joint at 6 months; 5 of 12 laser surgery–treated joints (Fig. 3) and 8 of 12 SD-treated joints (Fig. 4) had bone bridging the joint at 12 months. A significantly greater percentage of joint space was bridged by bone in the MIA-treated (51.4%) and SD-treated (46.2%) joints compared with the laser surgery–treated joints at 6 (30.6%) and 12 (28.5%) months, respectively.

The laser surgery technique and SD are complicated by the difficulty of keeping either within the curved joint spaces of the distal tarsus. Because of the contour of the DIT and TMT joints, the drill bit and laser fiber do not always remain within the joint and can penetrate the subchondral bone instead of following the articular surface. Problems as a result of the drill bit not following the articular surface were not identified in this study, however, whereas the laser fiber created subchondral bone defects in 2 horses when it did not remain within the joint space. Complications can occur with any arthrodesis technique; however, each of these techniques can be safely used to treat osteoarthritis of the DIT and TMT joints. Care must be taken to ensure that SD and laser surgery are directed into the joint and that MIA is injected without leakage into the soft tissues. Experience and intraoperative imaging are essential to perform these procedures successfully.

Fig. 3. Sagittal microradiograph of the distal tarsus of a horse treated with laser surgery 12 months previously. Note the ring of subchondral bone sclerosis surrounding the treatment area. The area of sclerosis appears to be the extent of the direct effects of laser surgery.
Because of the relatively focal area of severe cartilage and subchondral bone damage associated with laser surgery, it may be necessary to modify the technique to promote more rapid and complete fusion. Performing laser surgery at two or three locations within the joint would destroy more articular cartilage, similar to that which occurs with surgical drilling. This may encourage more complete fusion, although still gaining the beneficial effect that the laser energy seems to have on the innervation of the subchondral bone, synovium, and joint capsule.

This study demonstrates that laser surgery resulted in less fusion of the DIT and TMT joints compared with the other two techniques. MIA and SD produced comparable amounts of bone bridging the joints when compared at 6 and 12 months, respectively. Laser surgery resulted in bone bridging the joint space in only 7 of 24 joints, and the smallest percentage of the joint space was bridged by bone compared with the other two techniques. Despite this observation, horses were more comfortable after surgery and most horses were less lame on the laser surgery–treated limb. This suggests that laser surgery may have a beneficial effect beyond fusion of the distal two tarsal joints.

Because of the difference in the postoperative comfort level between the SD- and laser surgery–treated joints in our study, it is difficult to recommend SD of the joint space. Therefore the authors currently use modified laser treatment or MIA to fuse these two joints. In some horses,
these two procedures are combined. In joints that are partially fused, a laser is passed through a drill hole across the joint in two or three locations; in many horses, it is frequently the DIT joint that is partially fused. The TMT joint is injected with MIA because it produces solid fusion of this joint with minimal risk of gaining access to the proximal intertarsal joint. This approach requires evaluation and follow-up in a number of cases before it can be recommended as the method of choice.

Arthrodesis of high-motion joints

Distal interphalangeal joint

Indications for arthrodesis of the DIP joint in horses are infrequent. Severe osteoarthritis, injury to the collateral ligaments that results in joint instability, rupture of the deep digital flexor tendon, septic arthritis, or chronic articular fractures can all be a cause of chronic pain making affected horses candidates for arthrodesis of the DIP joint [28]. Successful arthrodesis of the DIP joint of the horse presents numerous challenges. Because this is a high-motion joint, rigid internal fixation or prolonged external coaptation is necessary to allow bone to bridge the joint. The location of the DIP joint within the hoof capsule presents additional challenges for gaining access to the joint and for creating an aseptic environment in which to place implants. Anatomically, there is a relatively small area of the distal phalanx that can hold implants. In addition, the hoof capsule and laminae limit our ability to use DCPs to counteract the forces acting on this joint.

The DIP joint is approached through two incisions [28,29]. The first incision is made 1 cm proximal and parallel to the coronary band on the dorsal surface of the limb and is extended to the lateral and medial aspects of the joint. The common or long digital extensor tendon is transected along with the joint capsule. The collateral ligaments are partially transected to allow enough space for curettes to be placed into the joint. The joint is then partially luxated, and the articular cartilage on the second and third phalanxes is debrided. It is not possible to remove all the articular cartilage; however, it is important to remove as much as possible. An alternative approach is to place an arthroscope in the dorsal and palmar or plantar joint pouches and remove the articular cartilage with a motorized burr.

A second 8- to 10-cm longitudinal incision is made over the palmar or plantar surface of the pastern. The skin incision is made on the palmar or plantar surface midline of the limb from the proximal sesamoid bones distally to the heel bulbs. The incision is continued through the digital annular ligaments and tendon sheath. The deep digital flexor tendon is transected to gain exposure to the palmar or plantar surface of the second phalanx. The attachment of the straight distal sesamoidean ligament to the second phalanx is identified, and a vertical stab incision is created on
midline. The DIP joint is reduced and held in a weight-bearing position. A 3.2-mm drill bit is used to drill through the second phalanx from the palmar or plantar surface proximal to the dorsal distal surface, bisecting the articular surface from the dorsal to palmar or plantar surface. Positioning is confirmed with fluoroscopy or radiographs. A 4.5-mm drill bit can be used to make adjustments in the direction of the hole based on radiographs. The glide hole in the second phalanx is then over-drilled with a 5.5-mm drill bit. A 4.0-mm drill bit is used to create the thread hole in the third phalanx. A depth of 30 mm is sufficient in most horses and avoids penetrating the laminae and hoof wall. A countersink is used to create a uniform surface for the screw head to engage. The hole is measured and tapped in a routine manner, and one 5.5-mm cortical bone screw is inserted. Screw placement is confirmed with fluoroscopy or radiographs. Two additional screws are placed in the same manner lateral and medial to the central screw. Once all three screws are in position (Fig. 5), cancellous bone graft is harvested from the ipsilateral tuber coxae and placed into the dorsal and palmar or plantar surfaces of the DIP joint [30]. Dorsally, the common digital extensor tendon and joint capsule are reapposed with absorbable suture material. Palmarly
or plantarly, the deep digital flexor tendon is not reapposed. The tendon sheath is closed with absorbable suture in a simple interrupted pattern. Subcutaneous tissue and skin are closed routinely. The incisions are covered with a sterile nonadherent dressing, and a fiberglass cast is placed on the limb from the carpus or tarsus distally. A transfixation pin cast can be used to increase weight bearing on the affected limb when necessary. The cast is changed, and sutures are removed at 2 weeks. The cast is changed every 4 to 6 weeks depending on the horse’s comfort in the cast. Transfixation pin casts are usually maintained for 6 weeks, and the horse is then placed in a standard half-limb cast. Casts are normally maintained for approximately 8 to 10 weeks. After removal of the cast, it is important to make appropriate shoeing adjustments to allow for comfort and use of the limb. Radiographs are taken at 90 days. If bone is present in the joint space, horses begin hand-walking. The horse’s use of the limb determines how soon the horse is turned out in a small paddock (30 ft x 30 ft).

Arthrodesis has also been performed using transarticular lag screws in a cruciate pattern with and without stainless-steel baskets [31]. These techniques require a dorsal approach to the joint for debriding the articular cartilage; additionally, a flap in the dorsal hoof wall is necessary when stainless-steel baskets are placed in the joint.

Arthrodesis of the DIP joint is accomplished without internal fixation when infection is present [32]. In these horses, the joint is approached through a dorsal arthrotomy or with arthroscopy to debride the articular cartilage. The joint is packed with autogenous cancellous bone graft and antibiotic-impregnated PMMA implants, and the limb is placed in a half-limb transfixation pin cast [28]. The horse is usually maintained in a transfixation pin cast for 6 weeks and is then placed in a standard half-limb cast for another 6 weeks. The technique of using large cancellous bone grafts and external immobilization to fuse joints in the distal limb of the horse has been reported [15].

Arthrodesis of the DIP joint is complicated by the anatomy and the concentration of weight-bearing forces on the third phalanx in the most distal aspect of the limb. Internal fixation has been limited to lag screws, which do not always provide rigid immobilization. As a result, horses are not always as comfortable after arthrodesis of the DIP joint as they are after other fusion procedures. This increases the risk of laminitis in the contralateral limb, especially when the horse has been treated for a long time for chronic painful disease in the joint before performing the fusion.

Metacarpophalangeal and/or metatarsophalangeal joint

Arthrodesis of the metacarpophalangeal (MCP) and/or metatarsophalangeal (MTP) joint is performed in horses with traumatic disruption of the suspensory apparatus (bixial sesamoid fractures, rupture of the suspensory ligament, or disruption of the distal sesamoidean ligaments) or chronic
osteoarthritis of the MCP and/or MTP joint, which has resulted in loss of articular cartilage and chronic pain because of exposure of the subchondral bone. In either case, the purpose of the procedure is to restore comfortable weight bearing on the limb for salvage of the animal rather than to return the horse to athletic performance.

Several techniques have been described for performing arthrodesis of the fetlock joint [33–42]. Although recent techniques offer some biomechanical advantages in vitro [41], the technique first described by Bramlage [33] continues to be the most routinely used, with some minor modifications. The skin and subcutaneous tissues are incised dorsolaterally over the common digital extensor tendon, extending from the proximal metacarpus/metatarsus to the PIP joint. The incision is continued through the common digital extensor tendon, splitting it longitudinally, and through the dorsal joint capsule of the MCP and/or MTP joint. A second incision is then made laterally through the joint capsule and lateral collateral ligament of the MCP and/or MTP joint so that the joint can be luxated for debridement of the articular cartilage. Alternatively, a lateral condylar fracture can be created with an oscillating bone saw (after predrilling holes for fracture repair) to allow disarticulation of the joint; this approach is usually made through one dorsal skin incision. The articular cartilage of the first phalanx, the third metacarpal bone, and both sesamoid bones is removed with a curette or motorized burr. Osteostixis is performed on the subchondral bone plate of the third metacarpal bone and proximal phalanx. If there is traumatic disruption of the suspensory apparatus, a palmar or plantar figure-of-eight tension band wire is placed at this time with the limb in partial flexion to reconstruct palmar or plantar support for the joint biomechanically. Placement of 1.5-mm wire is accomplished through 3.2-mm holes drilled laterally to medially through the distal metacarpus/metatarsus and proximal phalanx; passing the wire in a figure-of-eight pattern is the most difficult part of the procedure. Use of an AO wire passer can greatly facilitate passage of the wire medially to laterally across the palmar or plantar aspect of the joint.

The joint is then reduced and placed in 10° of dorsiflexion, and the dorsal surface of the sagittal ridge of the third metacarpal bone is removed with a chisel to improve contact between the bone plate and the bone. A 14- to 16-hole broad DCP is contoured to fit the dorsal surface. Alternatively, a fetlock arthrodesis plate has recently become available (LCP-ACP; Synthes, West Chester, Pennsylvania). If a condylar fracture was created, it is repaired with two 4.5-mm cortical bone screws at this time. The plate should be placed so that screws in the distal four holes can be placed into the first phalanx. Minimal contouring of the plate is required. One screw is then placed through the plate and into the proximal phalanx in a routine manner. If the suspensory apparatus is intact, two 4.5-mm cortical bone screws are placed in lag fashion through the third metacarpal bone into the proximal sesamoid bones while the proximal end of the plate is elevated
approximately 1.5 cm from the surface of the third metacarpal bone. Using 4.5-mm screws increases the margin for error; if the positioning of the screw in the proximal sesamoid is not adequate, a 5.5-mm screw can be placed in a better position. Fixation of the proximal sesamoid bones allows the plate to be loaded against the distal sesamoidean ligaments, creating palmar or plantar support for the MCP and/or MTP joint. The plate is then loaded and attached to the third metacarpal bone with 5.5-mm cortical bone screws. The 5.5-mm screws are recommended to increase the cyclic fatigue strength of the bone-plate construct. Additional 5.5-mm transarticular lag screws are then placed across the fetlock joint on each side of the plate (Fig. 6).

The incision is closed routinely in three layers: the common digital extensor tendon, subcutaneous tissue, and skin. A fiberglass half-limb cast is applied to the distal limb for anesthetic recovery. If there are no complications, the cast may be maintained for 2 weeks; at that time, it is removed. The horse is routinely kept on broad-spectrum antimicrobials for 3 days. If there is associated soft tissue damage or vascular compromise to the skin, antibiotics may need to be continued until the soft tissues have healed. The horse is confined to a stall for 90 days, and radiographs are taken to evaluate bone bridging the joint. If bone is spanning the joint space, the horse may then be turned out into a small paddock for an additional 90 days.

Approximately 65% of the horses treated with this technique return to comfortable weight bearing [33,42]. Failures are typically related to laminitis of the contralateral limb or implant infection. Laminitis can be minimized by performing MCP and/or MTP joint arthrodesis soon after traumatic disruption of the suspensory apparatus or as soon as the animal begins bearing less than 50% of the normal weight-bearing forces in cases of chronic osteoarthritis. Implant infection greatly complicates this arthrodesis procedure. It not only decreases the horse’s comfort on the operated limb, increasing the risk of contralateral laminitis, but greatly increases the costs of medical care and prolongs the horse’s stay in the hospital. Although arthrodesis of the fetlock joint has become a more successful procedure, it still has a higher infection rate than other orthopedic procedures performed in the horse. This is related to the minimal soft tissue coverage between the skin and the implants and the soft tissue damage that can occur in horses with breakdown injuries. The management of complications like infection continues to improve the success of this procedure.

Open joint injuries or horses with chronic infections of the MCP and/or MTP joint can also be successfully arthrodesed using the same concepts already described for the interphalangeal joints. The articular cartilage is debrided through a lateral or medial arthrotomy incision that transects the collateral ligament or through dorsal arthrotomy incisions. Enough articular cartilage can be removed by passing a drill across the joint space to bring about fusion of the joint. The joint is packed with autogenous
cancellous bone and antibiotic-impregnated PMMA implants. The joint is stabilized by placing the distal limb in a transfixation pin cast with pins placed through the distal third of the metacarpus or metatarsus (Fig. 7).

Carpal arthrodesis

Partial or pancarpal arthrodesis is performed in horses with unstable large slab fractures of the carpal bones that result in carpal instability, multiple carpal bone fractures, or chronic severe osteoarthritis of the carpal joints causing severe lameness at a walk. Partial or pancarpal arthrodesis can be performed to restore comfortable weight bearing on the limb. Partial
Carpal arthrodesis is performed instead of pancarpal arthrodesis when possible, because maintaining partial range of motion in the carpus allows increased comfort and use of the limb. Partial carpal arthrodesis can be performed to fuse the radiocarpal joint or to fuse the carpometacarpal and middle carpal joints. Arthrodesis of the carpus is a relatively uncommon procedure, and there are few publications in the literature regarding this procedure [43–46].

One of the problems with carpal arthrodesis procedures is the difficulty in closing the skin over the two plates that are routinely used for internal fixation. We have found it beneficial to place tension sutures in the skin over the distal carpus and proximal one third of the metacarpus on the day before the surgical procedure. Presuturing the skin in this manner creates more skin over the dorsal carpus as a result of chronic tension on the skin for 24 hours before surgery. This relieves the tension on the skin incision during closure over the plates. The arthrodesis is typically performed with the horse positioned in lateral recumbency, which is determined by the location of the fracture within the carpus; most frequently, the lateral side of the limb is positioned downward to allow access to the medial side of the leg, where comminuted fractures more typically occur. The carpus is approached

Fig. 7. Arthrodesis of the infected MCP and/or MTP joint can be performed by debridement of the articular cartilage and packing the joint with large amounts of autogenous cancellous bone graft and antibiotic-impregnated PMMA. A transfixation pin cast can be used to increase the horse’s comfort on the limb.
through two vertical skin and subcutaneous incisions, one on either side of the extensor carpi radialis tendon. The incisions are extended through the joint capsule over the affected joints. The articular cartilage is debrided using a curette or motorized burr. One 4.5-mm broad DCP is contoured to fit the dorsolateral or dorsomedial aspect of the carpus, and a second narrow DCP plate is placed on the side opposite the broad DCP plate. Generally, six- or seven-hole plates are used (Fig. 8). Three screws in the third metacarpal bone or the radius are usually all that is needed for stable fixation. Extending the plates into the diaphyseal region of either bone increases the potential for stress concentration at the end of the plates. The medial arthrotomy incision exposes the radiocarpal bone, whereas the lateral arthrotomy incision exposes the intermediate carpal bone. Plates are positioned to gain maximum purchase in these two bones, preferably with 5.5-mm screws. In horses with severely comminuted carpal bone fractures, bone dowels may be used to fill defects created by the severe comminution [46]. For carpal arthrodesis procedures, 5.5-mm screws should be used in every hole unless marked angulation of the screw is necessary to avoid a fracture line. Cancellous bone graft is harvested from the tuber coxae and

Fig. 8. A broad and narrow DCP in position to arthrodese the middle carpal and carpometacarpal joints. Lag screws can also be used to reconstruct carpal bone fractures before placement of the plates.
placed into the joints. The joint capsule is closed over the plates whenever possible. The subcutaneous tissue and skin are closed routinely.

The entire limb is then placed in a transfixation pin cast. Four or five 0.125-inch (3.2-mm) pins are placed in a diverging pattern through stab incisions in the distal third of the radius. The pin cast increases the horse’s postoperative comfort and helps to protect the contralateral limb from developing supporting limb laminitis. The cast is typically changed at 2 weeks to allow suture removal. The transfixation pin cast is maintained for 6 weeks; at that time, the horse is changed to a sleeve cast for an additional 4 to 6 weeks.

The horse remains confined to a stall until there is radiographic evidence of bone bridging the joint. Once there is bone bridging the joint, the horse may have exercise in a small paddock for an additional 90 days while the arthrodesis is maturing.

Complications are common with carpal arthrodesis in horses, including supporting limb laminitis and implant infection. Timing of the procedure is important, because the technique is more successful in horses that have not been non-weight bearing for a prolonged period because of osteoarthritis or attempted conservative management of comminuted carpal fractures. Approximately 67% of the horses survive and achieve comfortable weight bearing on the limb [46].

Scapulohumeral joint arthrodesis

Arthrodesis of the scapulohumeral joint has been performed in cases of chronic severe osteoarthritis, subluxation, or articular fracture in miniature or small horses to return them to nonpainful use of the limb [47–49].

A curvilinear incision is created through the skin and subcutaneous tissue on the craniolateral surface of the shoulder, extending from midscapula to midhumerus. The incision is extended deep, caudal to the brachiocephalicus muscle, and transects the omotransversarius muscle. A portion of the biceps tendon is removed from its origin on the supraglenoid tubercle to accommodate the plate. Care must be taken to identify and avoid the suprascapular nerve during dissection. The insertion of the supraspinatous muscle is transected, and the muscle is retracted cranially away from the spine of the scapula. A portion of the origin of the deltoideus muscle on the humerus may also need to be transected to accommodate the plate. The joint capsule is then incised, and the articular cartilage of the humeral head and glenoid cavity is removed.

A 10 to 12-hole narrow DCP is contoured along the cranial scapular spine, over the supraglenoid tubercle, and along the humerus. The scapulohumeral joint is positioned at an angle of approximately 120° for contouring the plate. The plate is attached to the scapula and humerus using 4.5-mm cortical bone screws. The screws into the scapula should be angled caudomedially to obtain the greatest purchase along the spine of the
scapula. Two screws are placed in lag fashion across the joint through the plate to provide compression of the articular surface.

The biceps tendon and supraspinatus tendon are reapposed to their origin and insertion, respectively, using monofilament absorbable suture. Muscle layers are closed by apposing the fascia in a simple interrupted pattern of monofilament absorbable suture. The subcutaneous tissue and skin are closed routinely, and a stent is sutured over the incision. Horses should be assisted in recovery from general anesthesia to prevent unnecessary stress on the fixation. The horse is confined to a stall until there is evidence of bone bridging the joint and is then turned out into a small paddock. The horse should not be turned out in a large pasture for at least 6 months after the arthrodesis.

Horses that achieve stable bony fusion of the joint typically resume comfortable weight bearing on the limb; however, complications during the ankylosis process are not uncommon. Complications include implant infection, implant failure, and scapular fracture. Laminitis is not a common complication in this group of horses because of the small stature of the horses that are candidates for scapulohumeral arthrodesis.

References


