Transfixation cast technique for arthrodesis of the distal interphalangeal joint of horses

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Summary
Surgical arthrodesis of the distal interphalangeal (DIP) joint by transfixation casting was used to salvage a three-year-old filly and a yearling filly that were chronically lame because of infection of the DIP joint for breeding. Unlike previously described techniques for arthrodesis of the DIP joint, the technique used did not require insertion of implants across the joint, which may have contributed to the successful outcome.

Introduction
A common indication for arthrodesis of the distal interphalangeal (DIP) joint is irreversible damage to that joint. Causes may include instability, infection, advanced osteoarthritis, articular fracture, osteochondrosis, and traumatic injury to periarticular ligaments and soft tissue structures of the joint. The aim of arthrodesis is to relieve pain and improve function of the limb to salvage a horse that has value for breeding or as a pet (1–4).

The purpose of this report is to describe a technique for arthrodesis of the DIP joint that does not use transarticular implants, making it particularly useful for arthrodesis of a chronically infected DIP joint. This report describes the clinical findings, treatment, and outcome of two horses that underwent arthrodesis of the DIP joint using this technique.

Surgical technique of arthrodesis of the distal interphalangeal joint

Horses were anesthetised and positioned in lateral recumbency with the affected limb up. The superficial layer of horn was removed from the hoof wall and sole with a grinder, the sole and the most distal centimetre of the wall were covered with a latex glove, and the distal portion of the limb was aseptically prepared for surgery.

Two Steinmann pins (4.8 mm diameter Steinmann pins for horse 1, and 6.2 mm, positive-profile, threaded, large animal transfixation pins for horse 2) were placed in the distal aspect of the third metacarpal bone in standard fashion for application of a transfixation cast (5–7). Radiopaque markers were placed on the hoof wall to target the centre of the DIP joint. A window in the hoof wall, centred over the lateral aspect of the joint, was created using a 19 mm bone trephineb. The laminae were excised with a scalpel, and the hoof wall and laminae were elevated en bloc with an osteotome to expose the DIP joint. A 3.2 mm hole was drilled through the joint, from lateral to medial, using radiographic control to ensure that the drill bit was centred across the joint. This hole was sequentially enlarged using increasingly larger bits (4.5 mm, 5.5 mm, and 12.7 mm drills) (Fig. 1). A small amount of soft bone was removed from the margin of the 12.7 mm hole using a curette, but no effort was made to remove cartilage from the articular surfaces of the distal and middle phalanges or navicular bone. The hole was packed with alternating layers of polymethylmethacrylatec (PMMA) beads containing tobramycin (9.6 g of tobramycin/40 g of PMMA) and cancellous bone harvested simultaneously from the wing of the ilium by a second surgical team. Approximately 20, crudely fashioned beads, approximately 3 mm in diameter, were placed. The defect in the hoof wall was packed with cancellous bone to within 4 to 5 mm of the surface of the hoof wall, and 40 g PMMA containing 500 mg gentamicin, was placed over the defect in the hoof, flush with the hoof wall.

The PMMA patch was covered with a sterile dressing, and a fiberglass, transfixation cast that extended from the sole of the hoof to the proximal end of the metacarpus was applied to the limb.

Case reports

Horse 1
An eight-month-old, American Quarter Horse filly was referred because of lame-
ness of the right forelimb. At the onset of lameness, 3.5 weeks previously, an abscess in the medial portion of the sole of the right fore foot was identified and opened. One week later, because the filly was still lame, the abscess was again opened, and cephalothin sodium was administered for two weeks. The filly’s lameness improved during the next two weeks, but three days after antibiotic therapy was discontinued, the filly became acutely and severely lame, anorexic, lethargic, and pyrexic and was referred to the Texas A&M University Large Animal Hospital for evaluation and treatment.

We observed that the filly was severely lame (grade 5/5, grading scale of the American Association of Equine Practitioners [AAEP]) on the right forelimb. The digit of the right forelimb was swollen and hot, and the medial aspect of the sole of the hoof had a 2 cm diameter defect. Radiographic examination of the digit revealed an osteolytic area in the axial aspect of the medial wing of the distal phalanx with a large solar and subsolar defect superimposed over the area of osteolysis. The DIP joint space appeared to be wider than that of the contralateral limb. Synovial fluid obtained by centesis was amber and opaque and contained 6840 WBC/mL, 80% of which were degenerate neutrophils, and 5.3 g/dL of protein. The peripheral white blood cell count was 9300 cells/mL, and the serum fibrinogen was 900 mg/dL. Based on the above findings, we concluded that the cause of severe lameness was most likely infection of the DIP joint and osteomyelitis of the axial margin of the medial wing of the distal phalanx. Culture of infected subchondral bone obtained by curettage of the medial wing of the distal phalanx through the solar defect, produced a pure culture of Corynebacterium pyogenes.

Despite aggressive treatment for 11 days, the filly remained lame (grade 3/5 AAEP grading scale), and radiographic examination of the digit revealed osteolysis of the distal epiphysis of the middle phalanx and narrowing of the DIP joint space. Based on the progression of clinical and radiographic signs of infectious arthritis, surgical arthrodesis of the DIP joint was recommended to salvage the filly for breeding.

Phenylbutazone (2.2 mg/kg i.v. q12h), enrofloxacin (4 mg/kg p.o. q12h), and potassium penicillin (20,000 U/Kg i.v. q6h) were administered before surgery. The filly was fully weight-bearing on the affected limb by 72 hours after surgery and continued to bear full weight after the dosage of phenylbutazone was reduced (1.1 mg/kg i.v. q12hr) one week after surgery. At two weeks after surgery, the administration of penicillin was discontinued.

The cast was changed five weeks after surgery because the proximal transfixation pin was loose, causing the filly to become lame. Radiographically, arthrodesis of the DIP joint appeared to be progressing but was incomplete. The proximal pin was removed, and another cast was applied that incorporated the remaining pin. The filly was fully weight-bearing on this second cast. Administration of enrofloxacin and phenylbutazone was discontinued at this time.

The cast and remaining pin were removed two weeks later, when the pin loosened, and a bandage cast (a half-limb cast incorporating the foot placed over a padded bandage and bi-valved to allow for bandage change) was applied. At this time, fusion of the DIP joint radiographically appeared to be more advanced but was still incomplete (Fig. 2). The PMMA patch had loosened, so it was removed, revealing healthy granulation tissue. The filly was discharged to the owners.

The owners removed the bandage cast after a week. At this time, the filly was sound at a walk but moderately lame at a trot. The filly was euthanatized six months after surgery because she developed signs of severe colic, but she had remained sound at a walk until her death.

**Horse 2**

A three-year-old, American Quarter Horse filly was presented to the Performance Equine Associates equine hospital because of lameness (grade 3/5, AAEP grading scale) two weeks after receiving sodium hyaluronate and triamcinolone into the DIP joint of the left forelimb. A palmar digital nerve block of that limb caused the filly to become temporarily sound. No ossous abnormalities were observed during radiographic examination of the foot, but centesis of the DIP joint produced 3 mL of purulent synovial fluid that contained 16,371 nucleated cells/mL and 6.1 g/dL of protein. More than 80% of the cells were degenerate neutrophils. Gram-positive cocci later determined to be Staphylococcus aureus, were observed within the neutrophils. Based on the above findings, the severe lameness of the left thoracic limb was determined to be caused by infection of the DIP joint.

Despite aggressive treatment including joint lavage, debridement, and drainage, as well as administration of local, regional, and systemic antibiotics during the next five weeks; the signs of infectious arthritis persisted. The owner, after being advised of his options for continued treatment, which included euthanatizing the horse, requested an attempt at surgical arthrodesis of the DIP joint.
Procaine penicillin G (20,000 IU/kg i.m. q12h), enrofloxacin (5 mg/kg i.v. q24h) and phenylbutazone (4.4 mg/kg i.v. q12h) were administered before and immediately after the arthrodesis surgery. Five days after surgery, administration of penicillin was discontinued, and the dose of phenylbutazone was reduced (2.2 mg/kg i.v. q12h). Seven days after surgery, the route of administration of enrofloxacin and phenylbutazone was changed from intravenous to oral (enrofloxacin 7.5 mg/kg p.o. q24h; phenylbutazone 2.2 mg/kg p.o. q12h), and on day 14, the dose of phenylbutazone was decreased (2.2 mg/kg p.o. q24h). At day 16, the horse was discharged from the hospital to the owners, who were instructed to confine the horse to a stall and to continue oral administration of enrofloxacin and phenylbutazone.

The horse was returned for evaluation when it became lame (grade 3/5, AAEP grading scale) at a walk 16 days after being discharged (postsurgical day 32). Fracture of the proximal pin, at the bone-pin interface on the medial aspect of the metacarpus, was discovered during radiographic examination. The broken pin and the cast were replaced with the horse anaesthetised. When the horse was discharged two days later, it walked without lameness. The owners were instructed to continue administering enrofloxacin (7.5 mg/kg p.o. q24h) and phenylbutazone (2.2 mg/kg p.o. q24h).

The horse was lame (grade 3/5, AAEP grading scale) on the affected limb when it was returned to the hospital for a scheduled cast change two months after the arthrodesis. Radiographic evaluation of the distal portion of the left thoracic limb revealed that the hole created in the DIP joint had filled with bone (Fig. 3). With the horse anaesthetised, the transfixation pins were removed, and another half-limb cast was applied. The horse was sound at the walk with the new cast and was discharged to the owners, who were instructed to continue administering enrofloxacin and phenylbutazone. The cast was removed 10 days later, with the filly sedated, and a bandage cast was applied to the limb. The horse was discharged, and the owners were instructed to continue administering phenylbutazone and to discontinue administration of enrofloxacin.

Two weeks later, the bandage cast was split longitudinally in a frontal plane, and the limb was splinted with the palmar half of the splint. After two weeks, administration of phenylbutazone was discontinued, and limb support was reduced to a heavy bandage, which was removed after a week. The acrylic cap over the trephine hole in the hoof dislodged when the bandage was removed, revealing keratinised tissue.
At eight months after arthrodesis, the horse walked with only slight lameness (grade 1/5, AAEP grading scale) and was weight-bearing evenly on both forelimbs while resting. Radiographic examination revealed fusion of the navicular bone to the middle and distal phalanges, but fusion of the dorsal aspect of the middle and distal phalanges was incomplete. The defect in the hoof had reached the bearing surface of the hoof. A clipped, heart-bar shoe was applied to the foot to stabilise the hoof-wall defect until growth of the hoof resulted in its disappearance.

The horse was moderately lame at a trot when it was allowed unrestricted exercise at pasture nine months after surgery (grade 3/5 AAEP grading scale). One year after surgery, the horse oscillated between soundness and slight lameness (grade 1/5, AAEP grading scale) at a trot. Radiographic examination showed complete bony union of the middle and distal phalanges and the navicular bone (Fig. 4). Osteoarthritis of the proximal interphalangeal (PIP) joint was also evident radiographically. Based on results of diagnostic analgesia, we determined that the site of pain causing lameness was the proximal interphalangeal joint. Despite being mildly lame, the mare had a successful breeding season as a three-year-old, producing embryos for transfer to recipient mares.

By approximately two years after arthrodesis of the DIP joint, the mare had become more lame, apparently because of progression of osteoarthritis of the PIP joint (grade 3/5, AAEP grading scale). Amelioration of lameness by instillation of anti-inflammatory medication into the PIP joint was brief, and so, this joint was arthrodesed using a previously described technique (Fig. 5) (9, 10). At 32 weeks after the second surgery, the mare was sound at a walk, grade 1 lame at a trot (AAEP grading scale), and able to lope. She was still being used for breeding.

**Discussion**

The purpose of this report was to describe a technique of arthrodesis of the DIP joint that does not use transarticular implants. We hypothesised that such a technique would be useful to treat horses with chronic, infectious arthritis of the DIP joint refractory to other treatments. Infection of the DIP joint is a common problem in the horse, in our experience. Bacteria can enter the joint through wounds commonly sustained in the region of the hoof, or as occurred with one of the horses in our report, during administration of medication into the joint. Treatment of affected horses using local and regional antimicrobial therapy, in combination with vigorous joint lavage, is often successful if infection is recent, but chronically infected joints may require debridement and drainage, especially if the joint contains necrotic tissue (11). Debriding the DIP joint and establishing drainage are difficult because the joint is confined within the hoof capsule. Even if infection is eliminated, articular cartilage may be destroyed, leading to chronic, painful, degenerative arthritis.

![Fig. 4](image1.png) One-year, postoperative radiographs of Horse 2. A) Dorsopalmar radiographic view of the distal interphalangeal (DIP) joint. B) Lateral radiographic view of DIP joint showing bony fusion. Radiographic signs of osteoarthritis of the proximal interphalangeal joint are seen on the dorsopalmar and lateral radiographic views.

![Fig. 5](image2.png) Radiographs of Horse 2 demonstrating technique of proximal interphalangeal (PIP) joint arthrodesis. A) Dorsopalmar view of the PIP joint. B) Lateral radiographic view of the PIP joint.
Arthrodesis of the joint to relieve pain may be indicated when the affected horse becomes refractory to any other treatment. The technique of arthrodesis, when used to fuse an infected joint, should help eliminate, rather than perpetuate, infection.

Published techniques of arthrodesis of the DIP joint describe removal of accessible cartilage and compression of the joint using transarticular screws placed in lag fashion (1–4). The technique of arthrodesis of the DIP joint that we describe avoids introducing metallic implants into the joint, a feature we consider important for success if the joint is infected because metallic implants become colonised in a septic environment, harboring bacteria that sustain the infection until the implant is removed (12). Inability to resolve infection of the joint is likely to result in failure of the arthrodesis and ultimately in euthanasia of the horse.

Transfixation casting has been used to manage horses, cattle, llamas, and small ruminants for fracture of a long-bone (5–7, 13–21). In one report, transfixation casting was used successfully to treat a foal with an open, infected fracture of the third metacarpal bone (13). A transfixation cast provides immediate postoperative comfort to the animal by transferring weight-bearing from the diseased or injured portion of the limb to more proximal portions of the limb (7, 13). Stability provided by the transfixation cast allows the animal to bear more weight on the diseased limb, sparing the contra-lateral limb from complications associated with excessive weight-bearing, such as laminitis of the supporting foot. Transfixation casting also provides the maximum degree of stability possible without the use of transarticular, metallic implants (5–7). Providing stability reduces strain across the DIP joint, promoting primary bone healing.

Our approach to the DIP joint through a trephine hole in the hoof was a modification of an approach described to expose necrotic collateral cartilage that extends below the coronary band and was an approach suggested, but not used, by Honnas et al. in a report describing a technique for arthrodesis of the DIP joint (2, 22). An approach through the wall of the hoof provided good access to lateral aspect of the joint, was less invasive than the techniques of arthrodesis of the DIP joint reported by Schneider, et al., and allowed drainage by opening the distal most aspect of the joint (1).

Although we did not remove all of the articular cartilage, we achieved complete fusion of the proximal and distal phalanges and navicular bone, perhaps because cartilage inaccessible at surgery had already been destroyed by infection. The PMMA beads and cancellous bone, when packed into the cylindrical defect in the center of the joint, may have provided interdigitation that improved stability. Antibiotic impregnated PMMA beads provided a high, local concentration of antimicrobial drugs for an extended time to aid resolution of infection of the joint (23). Cancellous bone placed into the defect provided a biologic scaffold for ingrowth of tissue, and osteoblasts within the graft, although few in number, may have induced formation of new bone (24).

The second horse in this report developed osteoarthritis of the ipsilateral PIP joint, providing some support for the suggestion of some authors that increased strains across the PIP joint resulting from immobility of the DIP joint may predispose that joint to development of osteoarthritis (1–4). An owner of a horse undergoing arthrodesis of the DIP joint should be forewarned that the horse could develop osteoarthritis of the ipsilateral PIP joint and that to eliminate pain associated with osteoarthritis of the PIP joint, arthrodesis of that joint may be necessary.

To our knowledge, the technique of arthrodesis of the DIP joint that we describe is the only report of a technique of arthrodesis that does not use transarticular implants. The advantages of our technique over other reported techniques, when fusing an infected DIP joint, include provision for drainage (through and around the PMMA patch), local delivery of antimicrobial therapy using PMMA beads, and avoidance of metallic implants in an infected environment (1–4). The outcome of arthrodesis for both horses in this report was good, and we believe the technique warrants consideration by others for treatment of horses with septic arthritis of the DIP joint refractory to other treatments.

The technique used for arthrodesis of the DIP joint of the two horses in this report may prove to be useful for arthrodesis of the DIP joint for reasons other than unremitting infection of the joint.

References