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Proximal interphalangeal joint arthrodesis using a combination plate-screw technique in 53 horses (1994–2003)

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Keywords: horse; proximal interphalangeal joint; arthrodesis

Summary

Reasons for performing study: **A method for proximal interphalangeal joint (PIP joint) arthrodesis that provides a stable fixation and minimal duration of cast support is evaluated retrospectively.**

Objectives: **Evaluate the clinical use of a combined plate-screw method for PIP joint arthrodesis in a large number of horses.**

Methods: **The records of 53 horses undergoing PIP joint arthrodesis were reviewed. Arthrodesis was performed with a dorsally placed 3-, 4- or 5-hole narrow dynamic compression plate (DCP) with 2 transarticular cortex screws placed in lag fashion either side of the plate. Subject details, clinical presentation, radiographic findings, surgical technique, post operative treatment and complications were recorded. Long-term follow up (mean 3 years) was obtained for 46 horses.**

Results: **Arthrodesis procedures (n = 58) were performed on 53 horses with a DCP in combination with transarticular cortex screws placed in lag fashion. Conditions treated were osteoarthritis (OA) of the PIP joint, fracture of middle phalanx, PIP joint subluxation, subchondral cystic lesions and degenerative joint disease secondary to sepsis. Time of post operative cast application was 14 days. Overall 40/46 (87%) horses could be used as intended including 20/25 (81%) forelimb and 20/21 (95%) hindlimb arthrodeses. Twenty-three of 27 (85%) horses used for performance had successful outcomes. Complications included implant infection, cast sores and partial implant failure.**

Conclusions: **PIP joint arthrodesis using a DCP and transarticular cortex screws placed in lag fashion provides a stable construct and short casting period with minimal complications. The prognosis for return to performance was excellent for horses treated with hindlimb PIP joint arthrodesis and good for forelimb arthrodesis.**

Potential relevance: **Use of a combination technique for PIP joint arthrodesis allows a high proportion of horses with pastern joint disease to be returned to their athletic potential.**

Introduction

Degeneration of the proximal interphalangeal (PIP) joint is a common cause of lameness in many breeds and disciplines of horses. Osteoarthritis (OA) of this articulation can be initiated by a single traumatic event or as a result of chronic overuse injury. Other common causes include developmental orthopaedic disease and infection. Biomechanically, the PIP joint is a low motion joint responsible for bearing high loads, making it unforgiving of injury and inflammation (Auer 2006). Pastern joint OA is characterised by progressive cartilage loss and periarticular new bone formation. Lameness is often insidious at first and becomes severe in later stages of the disease. Radiography confirms the diagnosis of pastern OA demonstrating variable amounts of periarticular new bone formation, loss of joint space and subchondral bone remodelling.

Surgical PIP joint arthrodesis is performed with the goal of eliminating motion at the articulation in horses who fail to respond to systemic and intra-articular anti-inflammatory medication. Most previous reports describe the use of transarticular lag screws in various configurations to achieve arthrodesis (Martin *et al.* 1984; Caron *et al.* 1990; MacLellan *et al.* 2001). More recently a technique combining transarticular cortex screws placed in lag fashion with various number and configuration of dynamic compression plates (DCPs) was reported (Schaer *et al.* 2001).

Potential complications, related to surgical arthrodesis of the PIP joint, include construct failure, implant infection, excessive new bone formation, persistent post operative lameness, cast-related morbidity and subsequent pathology in the distal interphalangeal joint (Martin *et al.* 1984).

The purpose of this study was to report results of PIP joint arthrodesis with a narrow DCP combined with transarticular screws in a large number of horses. Outcomes were assessed relative to breed, sex and age of the individual, affected limb, preoperative radiographic changes, surgical technique and presence of complications. It was hypothesised that a combined plate/screw technique would provide a stable construct and allow a minimal casting period as arthrodesis progressed.

Materials and methods

Case selection

Medical records of horses admitted to Texas A&M University's Large Animal Hospital between 1993-2003 treated with PIP joint arthrodesis for lameness attributable to the PIP joint were reviewed. The diagnosis of PIP joint disease was made following

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Fig 1: Lateromedial radiographic projection of pastern arthrodesis with a 4-hole narrow dynamic compression and 2 transarticular lag screws.

presentation or prior to admission by the referring veterinarian. Only horses treated using 2 abaxially placed transarticular cortex screws, placed in lag fashion combined with a single dorsally applied DCP, were included. Horses with significant instability due to comminuted fractures of the PIP joint were excluded. Subject details, clinical history, radiographic findings, details of treatment and outcomes were retrieved for 53 horses.

Surgical procedure

Surgery was performed with the patient under general anaesthesia in lateral recumbency with the affected limb uppermost. A tourniquet was not applied and the distal limb was prepared aseptically. An inverted 'T' skin incision followed by an inverted 'V' incision through the common/long digital extensor tendon provided exposure to the pastern region. If necessary, bony proliferations on the dorsal aspect of the pastern were removed. The PIP joint was disarticulated by sharply transecting the entire medial and lateral collateral ligaments and the dorsal joint capsule. A bone curette was used to remove as much of the articular cartilage as possible from the proximal and middle phalanges. Osteostixis of both subchondral bone plates was performed at 0.5 cm intervals using a 2.5 mm diameter drill bit. No cancellous bone grafts were used.

With the joint held in maximum extension, using standard technique supported by radiographic or fluoroscopic control a 3-, 4- or 5-hole narrow dynamic compression plate was contoured to the dorsal aspect of the PIP joint and secured with cortical bone screws.

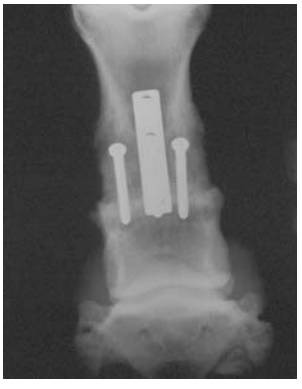

Fig 2: Craniocaudal radiographic projection of pastern arthrodesis with a 3-hole narrow dynamic compression plate and 2 transarticular lag screws.

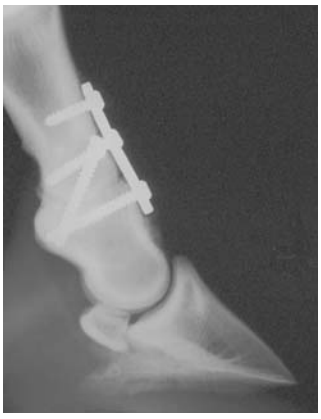

Fig 3: Lateromedial radiographic projection of pastern arthrodesis with a 3-hole narrow dynamic compression plate and 2 transarticular lag screws.

For 4- (Fig 1) and 5-hole plates the most distal screw, placed in load fashion was placed bicortically across the proximal aspect of the middle phalanx. The next proximal screw, placed in load fashion was placed bicortically in the distal first phalanx. The remainder of the screws were placed bicortically in neutral fashion into the first phalanx. All screws were 5.5 mm cortex screws. For 3-hole plates (Figs 2 and 3) the most distal screw was placed across the proximal aspect of the middle phalanx and the middle plate screw in the distal aspect of the proximal phalanx. Both of these screws were placed in load fashion. The most proximal plate screw was placed unicortically in neutral position. The 2 distal screws were 5.5 mm cortex screws and the proximal screw was a 4.5 mm cortex screw. In all patients, two 5.5 mm cortex screws were placed parasagitally in lag fashion on either side of the plate from the distal and dorsal aspect of the proximal phalanx into the palmar/plantar eminences of the middle phalanx. A countersink was used to allow the screw heads to be recessed in the first phalanx. Care was taken to avoid damage to the soft tissue structures of the palmar/plantar aspect of the PIP joint during drilling, tapping and screw insertion and to ensure that the screws did not extend beyond the palmar/plantar aspect of the proximal phalanx.

Closure

The extensor tendon was reapposed with synthetic absorbable suture in a tension-relieving pattern (near-far-far-near). The skin was closed with a combination of synthetic nonabsorbable suture and stainless steel staples. A fibreglass cast, extending to the proximal metacarpus/tarsus, incorporating the hoof was applied with the limb in extension with a slight heel wedge. Horses were recovered from anaesthesia with the assistance of a head and tail rope in a padded recovery stall.

Drug therapy

Tetanus toxoid[1] was administered once preoperatively i.m. Perioperatively horses were administered penicillin G potassium (Phizerpen)[2] (22,000 iu/kg bwt i.v. q.i.d.) and gentamicin sulphalte (GentaVed)[3] (6.6 mg/kg bwt i.v. s.i.d.) for 5 days. Phenylbutazone[4] (4.4 mg/kg bwt) was given i.v. prior to surgery. In some cases, either trimethoprim-sulpha (Sulphamethoxazole 800 mg and Trimethoprim 160 mg USP)[5] (30 mg/kg bwt *per os* b.i.d.) or doxycyline tablets USP[6] (10 mg/kg bwt *per os* b.i.d.) was admininistered until cast removal. Phenylbutazone (2.2 mg/kg bwt

i.v. or *per os* b.i.d.) was administered for a variable period depending on the comfort level of the horse.

Post operative care

Casts were removed routinely 14 days after surgery following radiographic confirmation of implant integrity with the patient standing and sedated and the limb placed in a padded pressure bandage. Horses were discharged with instructions to maintain a bandage on the limb for 3 weeks. Owners were instructed to confine the horse to a box stall for 3 months. During the first 6 weeks, daily hand-grazing was allowed with a progressive programme of hand-walking exercise instituted during the second 6 weeks of confinement. Horses were re-examined and radiography performed 3 months post operatively. Barring complications, horses were introduced gradually to free paddock exercise. A minimum of 3 months of paddock exercise was recommended before reintroducing them to riding activities.

Follow-up

Follow-up information was obtained by questionnaire and phone interview with owners or referring veterinarians as well as by repeat evaluation. Success was defined as owner satisfaction and return to previous performance level or intended use. Follow-up information included current use of the horse, performance level, time from surgery, and the appearance of the affected pastern. Follow-up radiographs were evaluated for degree of bony proliferation, completeness of arthrodesis, and evidence of complications. Minimum follow-up time to assess performance level was one year.

Statistical analysis

The Fishers exact test was used to determine associations between use, limb, primary lesion, preoperative radiographic changes and type of implant and outcome. A value of $P<0.05$ was considered significant.

Results

Subject details are summarised in Table 1. Median weight of horses at admission was 473 kg (range 68–906 kg). The majority of horses were mature, median age 9 years (range 2 weeks–22 years).

History

Reasons for arthrodesis included PIP joint OA in 25 cases (47%), closed PIP joint subluxation in 11 (21%), subchondral bone cysts of the PIP joint in 7 (13%), fracture of the middle phalanx in 6 (11%) and PIP joint OA secondary to septic arthritis in 4 (8%). The hindlimbs were more often affected in horses with subluxation (n = 8; P = 0.009) and middle phalangeal fractures (n = 5; P = 0.089). Fractures consisted of uniaxial palmar/plantar eminence fractures of the middle phalanx. Three horses had arthrodesis performed within several days of the fracture occurring. The other 3 horses had chronic lameness due to fracture, one of which had been repaired previously with a single lag screw and had subsequently developed OA of the PIP joint. Forty horses were considered to have chronic injuries (clinical signs present for over one month) and 13 presented less than one month after the onset of clinical signs. Treatment prior to arthrodesis consisted of rest, intra-articular medication, shoeing changes, lag screw fixation of a plantar eminence fracture, and extracorporeal shock wave therapy. Horses with previously septic pastern joints had been treated with parenteral and local antibiotic drugs, repeated lavage of the joint and treatment of associated wounds. Arthrodesis was performed in this group of horses due to persistent lameness 5 weeks to 8 months following treatment for joint sepsis.

Clinical signs and physical examination findings

Twenty-three horses (53%) were noted to a have visible thickening of the affected pastern. The horses were *grade 4* (n = 17), *grade 3* (n = 15), or *grade 2* (n = 2) out of 5 lame at presentation. Nineteen horses were noted to be lame but grade of lameness was not recorded. Perineural and/or intra-articular anaesthesia was used to confirm the pastern joint as the source of lameness following or prior to admission by the referring veterinarian.

Preoperative radiographic findings

Dorso-palmar/plantar, lateromedial, palmar/plantar lateral-dorsomedial and dorsolateral-palmar/plantar medial radiographic views were evaluated for all cases. The joint space was evaluated on the dorso-plantar/palmar view and was considered to be normal in 17 (32%), minimally collapsed in 13 (25%), moderately collapsed in 8 (15%), and severely collapsed in 15 (28%). Twenty-four horses had asymmetrical joint collapse (13 medial and 11 lateral), and 11 had symmetrical joint collapse. There was no radiographic evidence of periosteal new bone proliferation around the PIP joint in 18 horses (34%), minimal in 9 (17%), moderate in 20 (38%) and severe in 6 horses (11%). Horses with no bone proliferation also had joint collapse, subluxation or fracture. Subchondral bone lysis was noted in 6 horses.

Treatment

Fifty-three horses had arthrodesis performed, 32 (60%) had a 3-hole DCP applied in combination with 2 cortex screws placed in lag

TABLE 1: Subject details of 53 cases according to gender, breed and usage; and distribution between affected limbs

Gender	Gelding	Mare	Stallion							
	25 (47%)	17 (32%)	11 (21%)							
Affected limb	Forelimb	Hindlimb	Bilateral forelimb	Bilateral hindlimb						
	27 (51%)	21 (40%)	1 (2%)	4 (7%)						
Breed	Quarter Horse	Arabian	Peruvian Paso	Warmblood	Thoroughbred	Appaloosa	Paint	Miniature	Percheron	Saddlebred
	23 (43%)	7 (13%)	6 (11%)	4 (8%)	3 (6%)	3 (6%)	2 (4%)	2 (4%)	1 (2%)	1 (2%)
Use	Pleasure riding	Showing	Roping	Breeding	Jumping	Racing	Cutting	Barrel racing		
	12 (23%)	11 (21%)	9 (17%)	10 (19%)	3 (6%)	2 (4%)	2 (4%)	1 (2%)		

fashion and 19 (36%) had a 4-hole DCP applied. In 2 horses of large size, a 5-hole DCP plate was used. In one horse being treated following pastern sepsis, the plate was luted (bone cement placed under and around the plate prior to screw tightening) and antibiotic impregnated polymethylmethacrylate (PMMA) beads were placed in the soft tissues prior to closure. Disarticulation was impossible in one horse due to the extensive bony proliferation. In this horse, implant placement performed was placed under flouroscopic guidance without curettage of the articular surface. Surgery time averaged 2.4 h (range 1.5–3.8 h). Bilateral arthrodeses were performed simultaneously by 2 surgical teams (n = 3) or staged, with 2 months between procedures (n = 3). Mean time for post operative cast application was 14 days (range 12–27 days). Fifty horses (93%) wore a cast for less than 15 days and had only a single cast applied. Four horses required a second cast due to breakage of the first. Partial thickness cast sores were seen in 6 horses (11%) with the dorsal aspect of McIII/MtIII and the palmar/plantar aspect of the fetlock primarily affected. One horse developed a superficial digital flexor tendon lesion secondary to a severe cast sore. The median time of hospitalisation was 24.8 days (range 5–96 days).

Outcome

All horses (except for one which developed femoral nerve paralysis) were fully weightbearing at the walk within 72 h of surgery, remained comfortable following cast removal and were discharged from the hospital. Follow-up information was available for 46 of 53 horses, mean 3 years from surgery to follow-up (range 1–8 years). Forty-three of 46 horses were alive and 3 had died due to unrelated causes. Forty (87%) horses with follow-up could be used as intended including 20/25 (81%) forelimb and 20/21 (95%) hindlimb arthrodeses. There was a trend towards significance for outcome of horses with hindlimb arthrodeses to be more successful than those with forelimb arthrodeses (P = 0.198). Thirty-two of 38 (84%) horses intended for performance or pleasure riding were successful including 15/20 (75%) horses with forelimb and 17/18 (94%) horses with hindlimb arthrodeses. In a more detailed analysis of results, 23/27 (85%) horses used for performance (not breeding or pleasure riding) functioned at their intended level including 8/11 (73%) with forelimb and 15/16 (94%) with hindlimb arthrodesis. The difference in outcome between horses used for performance and pleasure riding was not statistically significant (P = 1.0). Twenty-five of 27 (93%) horses treated with a 3-hole DCP and 15/17 (88%) with a 4-hole DCP had successful outcomes (P = 0.63). After bilateral arthrodesis, 4/5 horses had successful outcomes. Forty-three (91%) owners were satisfied.

Successful outcomes were reported in 18 of 21 (86%) horses with OA and all horses treated for subluxation (n = 9), subchondral bone cysts (n = 6) or fractures of the middle phalanx (n = 6). Of the 4 horses with previously septic pastern joints 2 were used as intended (one following implant removal). The other 2 horses were ridden at a lower level (n = 1), and retired as a broodmare (n = 1) due to persistent lameness. Statistically, horses with previously septic PIP joints did not appear to have less successful outcomes (P = 0.077). All 10 horses intended for breeding were successful. Duration of convalescence averaged 9.5 months (range 3–12 months) in horses used for performance.

Implant removal was performed in 10 horses at 5–9 months following placement. Six horses developed signs of implant infection including radiolucency around implants (n = 6), excessive osteoproliferation (n = 4), persistent lameness (n = 6), and draining tracts (n = 2) post operatively. Implants cultured at removal yielded bacterial organisms (*Enterobacter* spp., *Streptococcus zooepidemicus*, *Staphylococcus* spp., and *Pseudomonas* spp.) in 4 of 6 horses. Two horses with implant infections (including the one in which the plate was luted) had originally been treated for septic arthritis, although a positive culture was not statistically associated with previous infection (P = 0.47). Four horses had elective implant removal due to owner concern over possible interference of the implants with future performance (n = 2) or cosmetic reasons (n = 2).

Post operative radiographs were available in 37 horses, in 8, taken 6 months or more after surgery, complete obliteration of the PIP joint space was noted and in 29, taken less than 6 months post operatively, arthrodesis had progressed but was not complete yet. Compared with preoperative radiographs, no periosteal new bone formation was evident or was mild in 26/37 (70%), moderate in 9/37 (24%), and severe in 2/37 (5%) horses. One of 53 horses (2%) had minimal preoperative proliferation, developed bony proliferation that impinged on the distal interphalangeal joint following arthrodesis and was not able perform as intended. While exostosis of the extensor process of the distal phalanx was noted in 4 horses with forelimb and only 1 horse with hindlimb arthrodesis, this difference was not statistically significant (P = 0.35). No lameness was appreciated post operatively in 4 of these horses. In one horse with radiographic signs of infection (bony lysis), a broken transarticular screw was removed. In another horse a broken plate screw was noted on post operative radiographs. The construct was stable and implant removal was not performed. Three horses with unsuccessful outcomes were ridden at a lower level and 2 were used as broodmares.

Discussion

Horses in this study were intended to be used for athletic purposes, pleasure riding or breeding. With overall 87% of horses returning to intended use, including success rates of 81% for forelimb arthrodesis and 95% for hindlimb arthrodesis, a combination plate-screw technique for PIP joint arthrodesis provides a high likelihood of returning horses with PIP joint disease to their intended function. The results of our study compare favourably with those from studies of horses arthrodesed with a transarticular lag screw technique (Martin *et al.* 1984; Caron *et al.* 1990; McLellan *et al.* 2001; Schaer *et al.* 2001), although direct comparison of outcomes may not be feasible due to differences in criteria for success and use of horse. By combining the results of these 4 studies 76/97 (78%) were considered successful, including 28/41 (68%) forelimb and 48/56 (86%) hindlimb arthrodeses. While no statistical difference in outcome was found between the results of our study and previous reports (P = 0.26), the combination plate-screw technique does appear to have several advantages.

Benefits of the technique are related to increased stability of the construct as well as lower morbidity and cost related to prolonged cast support. In the transarticular screw technique compression is applied primarily in the frontal plane allowing for the potential for considerable dorsal-palmar/plantar instability leading to discomfort and increased bony proliferation (Auer 2006). With the combined plate-screw technique compression is applied on the dorsal aspect of the PIP joint with a DCP and across the joint with transarticular lag screws. This leads to less instability during weightbearing and provides a more stable construct based on *in vitro* biomechanical testing (Easter and Watkins 1998). This more stable construct

encourages an earlier return to pain-free weightbearing and allows a shorter duration of post operative cast support. Previous studies have reported mean times for cast application for horses treated with transarticular lag screw techniques of 27 days (MacLellan *et al.* 2001), 57 days (Martin *et al.* 1984), 62 days (Caron *et al.* 1990), and 12 weeks (Schaer *et al.* 2001). Use of a DCP with transarticular screws for PIP joint arthrodesis has been reported in 15 horses (Schaer *et al.* 2001) mean casting time 5 weeks. Schaer *et al.* concluded that the combination technique provided a stable fixation that favoured rapid fusion of the PIP joint.

In our population, most horses walked comfortably following cast removal 14 days post operatively. Decreasing the duration of casting reduces cast morbidity and hospitalisation time and represents a major advantage of the plate-screw technique. However, with improved comfort and early cast removal, implants are subjected to increased cyclic loading. *In vitro* biomechanical testing, comparing cyclical load to failure of the 3-hole DCP combined with 2 transarticular cortex screws placed in lag fashion, has demonstrated it to be a more fatigue resistant construct compared to the 3 parallel 5.5 mm screw technique (Eastman and Watkins 2002). Post operative casting was utilised for the purpose of protecting the arthrodesis during anaesthetic recovery and promoting healing of the soft tissues.

In our population, the most common indication for surgical arthrodesis was primary OA of the PIP joint with 18/22 (82%) successful outcomes. Arthrodesis has been described as a primary treatment for uniaxial palmar/plantar eminence fractures of the middle phalanx (Watkins 1996). The predisposition for these fractures to occur in the hindlimbs of horses used in western performance events has been noted (Martin *et al.* 1984). Three of the 6 horses treated for fractures in our population were either used for team roping or cutting, and were affected in the right hindlimb. Although fixation of palmar/plantar middle phalangeal eminence fracture fragments may be achieved with lag screw fixation, degeneration of the PIP joint may progress and require subsequent arthrodesis, as was seen in one of our cases. In the present study, all 6 horses with fractures of the middle phalanx treated with the combination plate-screw technique returned successfully to athletic performance. Horses with middle phalangeal fractures accompanied by pastern joint instability are not candidates for the technique described here and are best treated with double plate fixation and extended periods of external coaptation (Crabill *et al.* 1995).

The treatment of septic PIP joints by surgical arthrodesis has been described previously in a small number of cases with half of those horses being subjected to euthanasia due to persistent lameness (Groom *et al.* 2000). Four horses in our study had arthrodesis performed to treat OA secondary to PIP joint sepsis. Only 2 of these were able to perform athletically after surgery. While statistically, these horses did not have a worse prognosis, a less optimistic prognosis for return to function is presented to owners along with the possibility that implant removal may be required. Although not required in all cases of PIP joint sepsis, arthrodesis is useful in allowing horses with refractory lameness following joint sepsis to be functional. Four horses in the present study developed an implant infection unrelated to previous septic arthritis, constituting a 7% infection rate. This underscores the importance of careful aseptic technique and appropriate perioperative antimicrobial therapy.

Post operative exostosis on the proximo-dorsal aspect of the distal phalanx in the area of the insertion of the common digital extensor tendon has been described previously (Martin *et al.* 1984), and could be due to change in the dynamics at the insertion of the extensor tendon following arthrodesis. Distal interphalangeal joint OA is another potential concern (Caron *et al.* 1990) and the distal end of the DCP should be placed as proximal as possible on the middle phalanx to avoid interference with the extensor process of the distal phalanx and joint capsule of the dorsal aspect of the distal interphalangeal joint. Clinically significant distal interphalangeal joint disease was recognised in only one of our horses. The degree of PIP joint degeneration seen radiographically prior to surgery was not statistically predictive of whether or not a horse would have a successful outcome. Subjectively, horses with minimal radiographic signs of PIP joint degeneration prior to surgery appeared to have shorter convalescence and were less likely to have excessive new bone formation around the PIP joint.

In conclusion, this study demonstrated that PIP joint arthrodesis using a dorsally placed DCP in conjunction with 2 abaxially placed 5.5 mm transarticular cortex screws applied in lag fashion promotes return to function following a limited period of external coaptation. The prognosis for return to intended function is excellent for hindlimb and good for forelimb arthrodesis.

Manufacturers' addresses

[1]Fort Dodge Laboratories Inc., Fort Dodge, Iowa, USA.
[2]Pfizer, New York, New York, USA.
[3]Vedco Inc., St. Joseph, Missouri, USA.
[4]RX Veterinary Products, Grapevine, Texas, USA.
[5]Mutual Pharmaceutical Co., Philadelphia, Pennsylvania, USA.
[6]Watson Laboratories, Corona, California, USA.

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