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Proximal interphalangeal arthrodesis in 22 horses

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Summary

The purpose of this study was to evaluate a new method of internal fixation technique for pastern arthrodesis. Pastern arthrodeses are performed commonly in horses with chronic osteoarthritis of the pastern joint or, in cases of acute traumatic injury to the pastern, in which the weightbearing bony column must be restored. Chronic osteoarthritis of the pastern is a frequent cause of lameness in the equine athlete and is evidenced by chronic lameness localised to the pastern joint, and supported radiographically by periosteal proliferation and loss of joint space. Nonsurgical and surgical treatments have both been described in the literature. Complications following pastern arthrodesis have been reported on several occasions and appear to focus on excessive periarticular exostoses and increased time in a cast due to prolonged time to bony fusion.

The hospital records of horses presenting for pastern arthrodesis to the Rood and Riddle Equine Hospital in Lexington, Kentucky, were reviewed and 22 met criteria for inclusion in the study. Horses with chronic osteoarthritis of the proximal interphalangeal joint or horses with an acute traumatic injury to the pastern undergoing pastern arthrodesis with one of the following techniques were included in the study. Horses with severe comminution of the middle phalanx were excluded. Three 5.5 mm cortical bone screws placed in lag fashion alone or in combination with a 4 or 3 hole dynamic compression plate affixed with 4.5 mm cortical bone screws were compared. A lower limb fibreglass cast was applied in all cases. Period in cast, time to return to intended use, complications encountered and outcome were evaluated.

Seven of the 8 hindlimbs treated with the combination technique became sound. Three out of 6 of the front limbs treated with the combination technique became sound. Four of the 5 horses with hindlimbs, and one of the 2 with front limbs, treated with screws only returned to their intended use.

The type of internal fixation did not appear to influence the overall number of horses returning to the intended level of performance. The period spent in cast and the time to return to soundness were decreased in horses operated on using the combination technique. We concluded that, in the immediate postoperative period, the combination of the parallel screw technique with a dorsally-applied dynamic compression plate provides the most stable and secure fixation, minimising motion, expediting bone remodelling and therefore favouring rapid fusion of that joint.

Introduction

Proximal interphalangeal joint arthrodesis is performed in individuals with chronic osteoarthritis of the pastern joint and subsequent debilitating lameness, or in cases of acute traumatic injury to the middle phalanx in which the severity of the fracture necessitates joint fusion to restore a weightbearing bony column.

Chronic osteoarthritis of the proximal interphalangeal joint is a frequent cause of lameness in the equine athlete engaged in high-speed activity or events involving repetitive stopping and turning. Horses present with chronic, progressive lameness localised to the pastern, often associated with periarticular swelling. Radiographic evaluation often reveals periosteal proliferation surrounding the pastern joint, total or partial loss of joint space and occasional subchondral erosive lesions. Progression of the disease results in decreased quality of life and increased risk of laminitis in the contralateral limb.

Traumatic injury to the middle phalanx occurs commonly during abrupt sliding stops in western performance horses (Watkins 1996). Uniaxial and/or biaxial palmar and plantar eminence fractures result when the distal interphalangeal joint is loaded in torsion, with the fracture often exiting at the insertion of the superficial digital flexor tendon (Watkins 1997). Higher energy injury results in a comminuted fracture with subluxation of the proximal interphalangeal joint, significantly increasing the severity of the injury. Acute severe lameness observed on presentation is localised to the pastern on clinical examination, and radiographs confirm the diagnosis.

Nonsurgical treatment of osteoarthritis of the proximal interphalangeal joint using electrical stimulation (Johnson 1974) or external coaptation and confinement has been described described (Adams 1976). Return to function following nonsurgical treatment is often significantly prolonged. Surgical methods of pastern arthrodesis as treatment for osteoarthritis or traumatic injury include curettage of the joint or drilling of the subchondral bone, in combination with cortical screw fixation in lag fashion or T plate placement, followed by immobilisation (Steenhaut *et al.* 1985). A study comparing lag screw techniques reported superior union when screws were placed in parallel fashion (Genetzky *et al.* 1981). Techniques for surgical treatment of comminuted fractures of the middle phalanx described in the literature include application of a narrow dynamic compression plate (DCP) (Doran 1987), use of a broad DCP (Bukowiecki and Bramlage 1989), or two narrow DCPs, (Crabill 1995; Watkins 1996).

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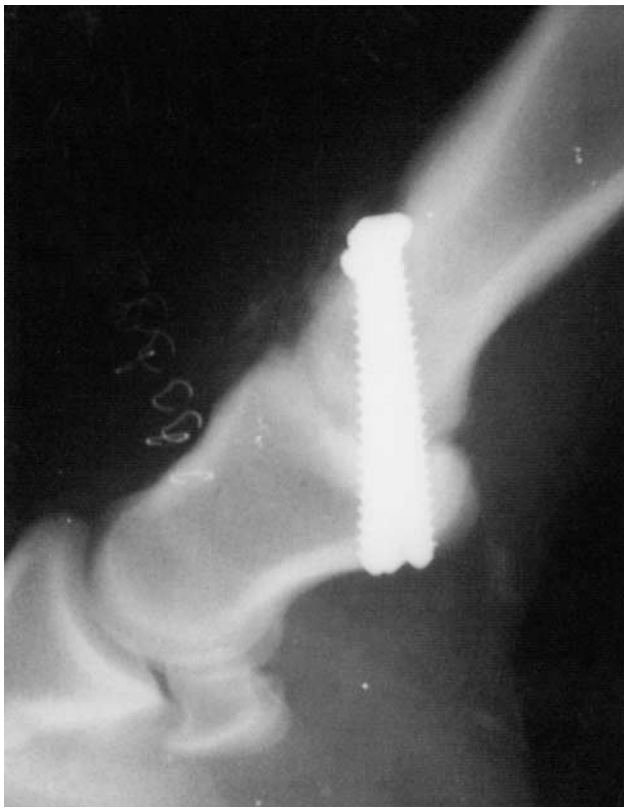

Fig 1: Implant placement of 5.5 mm cortical bone screws in lag fashion.

Fig 2: Implant placement of three 5.5 mm cortical bone screws in lag fashion combined with a 4.5 mm narrow DCP (4 hole) and four 4.5 mm cortical bone screws.

Complications following proximal interphalangeal arthrodesis include implant failure, lameness associated with excessive periarticular exostoses, toe elevation and increased period in cast (Martin *et al.* 1984). The purpose of this study was to describe the placement of 3 transarticular cortical screws placed in lag fashion in combination with a dorsally applied 4 or 5 hole narrow DCP and to compare it with parallel cortical screws placed in lag fashion for proximal interphalangeal arthrodesis. Consistent observation of undesirable dorsal callus formation following parallel transarticular cortical screw placement in lag fashion resulted in the initiation of this novel combination technique by one author (L. R. B.). Period in cast, time to return to performance, complications encountered and subsequent owner satisfaction are described for both techniques.

Materials and methods

The medical records of 25 horses referred to Rood and Riddle Equine Hospital over a 12 year period (1986–1998) for proximal interphalangeal joint lameness treated by pastern arthrodesis were reviewed. Criteria for selection for inclusion were osteoarthritis and lameness, or traumatic injury requiring fusion of the proximal interphalangeal joint by one of the described methods.

Twenty-two horses with a diagnosis of trauma and/or osteoarthritis of the proximal interphalangeal joint confirmed via lameness examination, regional anaesthesia and radiography, and that underwent surgical treatment (arthrodesis) of the affected joint were evaluated. Horses with significant comminution of the middle phalanx and resultant severe joint instability were not treated with one of the described methods and were, therefore, not included in this study. Subject details, occupation, limb affected, surgical description, complications, days hospitalised, weeks in cast and months until sound were obtained from hospital records and owner communication. Follow-up information and owner satisfaction were obtained via a telephone survey. Radiographic data included radiographic findings at time of presentation, 2 month postoperative radiographs and long-term follow-up evaluation, if available. Successful outcome was defined as owner satisfaction and return to previous performance level or intended use following surgical intervention.

Statistical analysis

The Fisher's Exact test was used to determine any associations between categorical variables (age, gender, breed, limb affected), method of fixation and weeks in cast, months until sound, days hospitalised, and outcome. A statistical significance level of $P \leq 0.05$ was used. Logistic remodelling using robust error estimation was used to determine the dependency of outcome on limb involvement and on time until sound.

Surgery

Horses were placed under general anaesthesia, in lateral recumbency with the affected limb up. The limb was prepared aseptically and no tourniquet was used. An inverted 'T' incision was made through the skin over the dorsal aspect of the pastern. The horizontal limb of the incision was made 1 cm proximal and parallel to the coronary band. An inverted 'V' incision was made through the common digital extensor tendon and the joint capsule to expose the dorsal aspect of the proximal interphalangeal joint.

TABLE 1: Summary of breeds of 22 horses undergoing surgery

Number of horses	Breed
9	Thoroughbred
5	Quarter Horse
2	Arabian
3	Warmblood
1	Saddlebred

TABLE 2: Summary of occupation of 22 horses undergoing surgery

Number of horses	Occupation at time of presentation
5	Broodmares
2	Racing prospects
3	National level showjumping
2	Upper level dressage
5	Upper level western performance
3	Mid-level showjumping

The apex of the 'V' was located at the mid proximal phalanx and the incision extended to the lateral and medial margins of the joint. The suspensory ligaments of the navicular bone were transected, but the collateral ligaments left intact. Complete removal of the articular cartilage of the proximal interphalangeal joint was achieved using hand-held retraction and bone curettage. Both subchondral bone plates were perforated with a 3.2 mm drill bit forming 6–8 evenly distributed 5 mm deep perforations to ensure release of vascular and cellular elements of the cancellous bone into the joint cavity.

Three parallel transarticular 5.5 mm cortical bone screws in lag fashion (Fig 1): The three 5.5 mm cortical bone screws[1] were placed in lag fashion across the joint in a dorsoproximal to palmar- or plantarodistal direction. The dorsal cortex between screw holes was left intact. Using normograde drilling with a 195 mm/5.5 mm drill bit, the glide hole was started with the drill directed perpendicular to the dorsal cortex of the proximal phalanx. As purchase was achieved, the drill was inclined gradually to perforate the proximal phalanx midway between the dorsal and palmar/plantar joint margin. The 3 holes were spaced equally from medial to lateral across the joint, unless a fracture indicated altered positioning of one of the screws to improve purchase in the middle phalanx. After realigning the joint, the pilot holes were drilled with a 195 mm/4.0 mm drill bit. Care was taken to avoid violating the region of the navicular bone during drilling and screw placement in the proximal middle phalanx. A countersink was used to create a concentric depression in the distal proximal phalanx for the screw head. The depth of the hole was measured. The hole was tapped and the screws placed.

For a stable fixation, the optimal screw position in the dorsoproximal to palmar- or plantarodistal direction should have the screw crossing the joint palmar/plantar to the midpoint of the joint surface when viewed on a lateral to medial radiograph. This ensures maximal purchase in the middle phalanx. Intra-operative radiographs were taken to confirm appropriate implant placement.

Three parallel transarticular cortical bone screws combined with a 4 or 5 hole narrow or broad DCP (Fig 2): The placement of the 3 transarticular screws in lag fashion was performed first. Then a 4 or 5 hole narrow or broad DCP[1] was contoured to the dorsal midline of the joint and loaded in tension. In most horses, a narrow plate was used, but in 2, a broad plate was selected (surgeon's preference). Cortical bone screws 4.5 mm diameter were used in most repairs. The most distal screw (hole no. 1) was placed first to engage the middle phalanx, followed by the most proximal screw with the plate loaded in dynamic compression. Screw holes 2 and 3 were then filled in neutral position. Most screws were placed perpendicular to the dorsal cortex of the bone, but the second screw was directed distally and placed in lag fashion to purchase the palmar or plantar aspect of the proximal middle phalanx. The top (proximal) screw was often angled proximally into the proximal phalanx to gain more cancellous bone purchase.

Bone grafts derived from the bone removed during the creation of the 4.5 mm glide holes were used to pack the margins of the stabilised joint. Prior to closure, placement of the implants was evaluated via dorsopalmar or dorsoplantar and lateral to medial radiographic views.

Closure: In both procedures, the extensor tendon was closed with synthetic absorbable suture in a simple interrupted cruciate pattern, followed by closure of the subcutaneous layer with synthetic absorbable suture in a simple continuous pattern. Stainless steel staples were used for closure of the skin. A sterile nonadherent dressing was placed over the incision and a routine lower limb fibreglass cast incorporating the foot was applied in all cases, with the fetlock angle in a natural standing position. The horses were hand-recovered on a thick mat in a padded recovery stall.

Drug therapy: Perioperatively, the horses received gentamicin[2] (6.6 mg/kg bwt i.v. s.i.d.) and potassium penicillin[3] (22,000 units/kg bwt q.i.d. i.v.) 7 days. Tetanus toxoid[4] was given once i.m. preoperatively. Preoperative phenylbutazone[5] (4.4 mg/kg bwt) was given once i.v., followed *per os* (2.2 mg/kg bwt) b.i.d. for approximately 30 days, and then as needed.

Postoperative care: The cast was changed with the horse standing 2 weeks postoperatively and a similar lower limb fibreglass cast was applied, maintaining the fetlock angle in normal standing position. The horses were discharged after the first cast change with instructions for cast immobilisation and stall rest for a total of 2 months. Horses treated with the parallel screw technique returned to the hospital for cast changes as necessary. Horses with the dorsal plate and screw combination had the cast left in place for a total of 30 days, then removed without reapplication. Radiographic evaluation was performed on all limbs 2 months postoperatively. It was recommended that the attending veterinarian repeat the radiographic evaluation at 4, 6 and 12 months postoperatively. Stall rest for one month after cast removal was recommended, followed, after radiographic bony union was evident, by hand-walking exercises for 10–20 min with no turn-out. Radiographic bony union was defined as loss of subchondral bone definition over the articular surface. Further aftercare and timepoint for gradual return to exercuse was determined in collaboration with the attending veterinarian, based on additional radiographic evaluation of the animal's clinical progress.

Results

Adequate follow-up of at least 14 months was available for all 22 horses as summarised in Table 3. Of the 22 horses (22 limbs)

TABLE 3: Summary of type of repair, limb affected, time in cast, time until sound and outcome of 22 horses undergoing surgery

	Transarticular screws	Screws and plate
Total No. horses	7/22	15/22
Limb affected	5/7 HL and 2/7 FL	8/15 HL and 7/15 FL
Lesion at presentation	4/7 OA and 3/7 trauma	11/15 OA and 4/15 trauma
Time in cast*	Median: 12 weeks (range 6–14) Mean: 12.6 weeks	Median: 5 weeks (range 2–7) Mean: 4.8 weeks
Time until sound*	Median: 12 months (range 8–24) Mean: 12.4 months	Median: 8 months (range 6–12) Mean: 7.8 months
Successful outcome (15/22)	5/7	10/15
Sound horses with FL lesion	1/2	3/6**
Sound horses with HL lesion	4/5	7/8

*P≤ 0.05; **One horse eliminated due to fracture during anaesthetic recovery; HL = hindlimb; FL = forelimb.

surgically treated with an arthrodesis of the proximal interphalangeal joint, 45.5% were male (9 geldings, 3 colts) and 54.5% female. The median age was 6.0 years, range 1–13 years. The breakdown of the breeds and their occupations is shown in Tables 1 and 2. Fifteen horses in the study were athletes, 5 were Thoroughbred broodmares and 2 were Thoroughbred yearlings intended for racing. The athletic occupation consisted of national level showjumping (3 horses), upper level dressage (2 horses), upper level western performance events (5 horses), and mid-level showjumping (3 horses). Quarter Horses were over-represented compared to the usual hospital population.

Thirteen of the 22 horses (59%) surgically treated had a hindlimb lameness, compared to 9 with a front limb lameness. Fifteen of the 22 horses (68%) presented with chronic osteoarthritis and 7 with acute trauma. Of those with traumatic injury, 5 had palmar or plantar eminence fractures and 2 had a dorsal subluxation of the middle phalanx with no fracture.

An arthrodesis with 3 parallel transarticular screws placed in lag fashion was performed in 7 (32%) of the 22 horses, with 5 (23%) having their hind pastern and 2 (9%) their front pastern fused. All of these 7 horses were athletes. Four presented with osteoarthritis and 3 with trauma.

Pastern fusion with the combined technique of screws and a dorsal plate was performed in 15 (68%) horses of which 8 (31%) involved a hindlimb and 7 (36%) a front limb. Ten horses (45%) were athletes and 5 (23%) were broodmares. Eleven of the 15 (73%) presented with osteoarthritis and 4 (26%) with acute trauma.

Although the combined technique (dorsal plate and screws) resulted in a median of 13 days (range 4–49) of hospitalisation compared to a median of 16 days (range 12–18) with the parallel screw technique, no statistical association could be determined between the 2 techniques (P = 0.4).

There was a significant effect of method of fixation on the number of weeks horses spent in a cast (P = 0.05). The combined technique resulted in a median of 5 weeks (range 2–7) in cast immobilisation, compared to a median of 12 weeks (range 6–14) with the parallel screw technique. Similarly, there was also a significant effect of method of fixation on the number of months until horses were considered sound (P = 0.01). Horses treated with the combined technique were considered sound after a median of 8 months (range 6–12) postsurgery, compared to a median of 12 months (range 8–24) when operated on with the parallel screw technique.

Subjective assessment of the 2 month postoperative radiographic evaluation indicated that horses operated on with the combined technique had less callus formation compared to the group treated with the parallel screw technique. The parallel screw technique consistently demonstrated a proliferative bony response over dorsal P1. After the initial 2 month postoperative radiographic evaluation, the referring veterinarian performed most of the subsequent follow-up radiographs (suggested at 4, 6, and 12 months postoperatively). These films were unavailable and no statistical comparison could, therefore, be made.

On follow-up questioning of the owner concerning return to soundness and overall satisfaction, 15 horses had a successful outcome. Nine out of 13 horses returned to athletic performance at the same or a higher level, one returned to a showing career at the same level but with less success, one horse was sound but was electively retired from the show circuit to become a successful broodmare. One dressage horse returned to the show ring at a lower level. Three severely lame broodmares returned to normal breeding status with significant improvement in comfort level.

A successful outcome was achieved in 15 of the 22 horses (71.5%). Ten of 15 horses (67%) treated with the combined technique and 5 of 7 (71%) treated with the parallel screw technique became sound. Of the 7 horses with an unsuccessful outcome (28.5%), 5 were repaired with the combined technique. Six of these 7 showed radiographic evidence of fusion of the proximal interphalangeal joint, but lameness persisted. One horse with a hindlimb arthrodesis had a lameness subsequently localised to the tarsus upon re-examination, but the owner considered the surgical endeavour unsuccessful. In one horse considered unsuccessful with a forelimb arthrodesis, the postoperative pain and lameness was isolated to the distal interphalangeal joint upon re-examination. One horse was subjected to euthanasia due to a catastrophic fracture during recovery from general anaesthesia. This horse was categorised as a failure.

Eleven of 13 (84%) of the horses with hindlimb involvement became sound, compared to 5 of 9 (50%) presenting with front limb lameness. There was no statistical association between limb and outcome in this study (P = 0.3), although subjectively the data is suggestive of a correlation.

Categorical variables such as age, gender of the patient, presenting complaint and attending surgeon were evaluated to determine if an effect on outcome existed. There was no effect on successful outcome of attending surgeon, patient age or gender. The data suggest that a presenting complaint of osteoarthritis compared to trauma had a positive effect on successful outcome (P = 0.07).

Of the 7 horses that had successful outcomes treated with the

parallel screw technique, 2 had partial implant failure and therefore a prolonged time in a cast and time to return to soundness. No implant failures were observed with the combination plate and screw technique. One horse treated with the parallel screw technique developed severe cast sores, resulting in prolonged discomfort, but eventually went on to successful bony fusion of the pastern and return to its intended function. Due to the decreased cast time required with the combination plate and screw technique, severe cast disease was not encountered. One horse was subjected to euthanasia after a catastrophic fracture of the hindlimb proximal to the cast on recovery from anaesthesia. No postoperative infections were observed.

Reasons for categorising cases as a failure to return to intended level of soundness include the following. One horse had a prolonged convalescence of 24 months prior to returning to successful showing. Both Thoroughbred racehorses started race training at age 2 years. One became lame at an undiagnosed site before racing. The lameness was assumed to be related to the injured pastern joint. The second horse had not raced, but was considered a failure because the reason for not racing could not be documented. One horse successfully returned to rodeo performance with a residual lameness subsequently localised to its hocks (the owner still felt that surgical intervention had an unsatisfactory outcome). One horse was diagnosed with osteoarthritis of the coffin joint in the operated limb and subsequently dropped in level of performance.

In summary, 7 out of 8 of the hindlimbs treated with the combination technique became sound. All of the limbs appeared to have fused radiographically. The one lame horse in this group had the lameness localised to the hock. Three out of 6 of the front limbs treated with the combination technique became sound. Four of the 5 hindlimbs and one of 2 of the front limbs treated with screws only returned to their intended use.

Discussion

The 22 horses treated surgically in this study were predominately middle aged, with an even gender distribution. Several breeds were represented, but the Quarter Horse was the most common among the athletic group. This correlates well with previous reports (Colahan *et al.* 1981; Martin *et al.* 1984; Yovich *et al.* 1986; Caron *et al.* 1990; Watkins 1996). The majority of horses presented in this study were intended for athletic use. A larger number of horses with hindlimb involvement were treated surgically, compared to those with front limb involvement. This observation has been made in previous studies (Colahan *et al.* 1981; Caron *et al.* 1990; Watkins 1996). In general, the outcome for arthrodesis of the proximal interphalangeal joint in the pelvic limb is considered to be better than that for the thoracic limb (Schneider 1994). Horses with front limb lameness originating in the proximal interphalangeal joint may be less likely to be selected for surgical treatment, due to the impression of poorer prognosis for return to function. This may explain the smaller number of individuals surgically treated with front limb involvement in this study.

A successful outcome was achieved in 15 of the 22 (72%) horses treated surgically. Ten of 15 horses (67%) were treated with a plate and screws. Horses treated with this technique had significantly decreased cast time and an earlier return to soundness, when compared to horses treated with the parallel screw technique. Techniques using screws alone may result in less stability over the dorsal aspect of the arthrodesis, causing increased callus formation, prolonged patient discomfort and increased time spent in a cast. Longer cast time requires multiple cast changes, increased hospitalisation, greater cost to the client and increased risk for cast complications. Although cast time and time to return to soundness differed between groups, the number of failures in each treatment group was similar. Six horses in this study were considered a failure because they did not return to full function, despite radiographic evidence of bony fusion of the proximal interphalangeal joint. In 2 out of 6 of these cases, the failure of return to soundness was unrelated to the pastern joint. Two horses were considered failures because the reason for not racing could not be determined. The remaining 2 horses returned to performance, but one at a lower level and one after a prolonged convalescence.

Data presented in this study are suggestive of the presenting complaint having an effect on outcome. Horses with a presenting complaint of osteoarthritis seemed more likely to have a positive outcome. It is possible that the soft tissue damage, loss of ligamentous support, or involvement of more than one articular surface, often seen in acute traumatic injury of the pastern, may have a detrimental effect on outcome.

Occasional fracture of the distal portion of the proximal phalanx has been reported with parallel screw placement across the distal interphalangeal joint and, therefore, placement of 3 transarticular screws in a slightly converging fashion was advocated (Martin *et al.* 1984). All horses in this study had the 3 transarticular screws placed in lag fashion parallel to the long axis of the bone. No shelf was created in dorsal P1 for transarticular screw placement in any horse and no fractures of distal P1 were observed.

When confronted with performance-inhibiting lameness due to osteoarthritis or trauma to the proximal interphalangeal joint, surgical fusion of the pastern is the best alternative for athletic soundness. It also provides the best option for rapid bony fusion in horses suffering from chronic osteoarthritis. Horses with significant comminution of the middle phalanx develop severe joint instability. Additional internal fixation is required to restore the weightbearing bony column in these cases and such fractures cannot be approached using the methods described. The 3 screw technique with and without a plate was equally effective in terms of numbers of successful cases. The application of this combination technique did not improve the number of successful outcomes in horses with front limb arthrodesis. The combined technique of 3 parallel transarticular screws in lag fashion and a dorsal axial dynamic compression plate appeared to improve the strength and stability of the fixation and was not associated with any additional complications. Increased stability of the repair results in decreased motion at the arthrodesis, less callus formation, increased comfort, reduced duration of postoperative cast support and a more rapid return to function.

Manufacturers' addresses

[1]Synthes, Paoli, Pennsylvania, USA.
[2]Schering-Plough, Kenilworth, New Jersey, USA.
[3]Bristol-Myer Squibb, Princeton, New Jersey, USA.
[4]Bayer Corporation, Shawnee Mission, Kansas, USA.
[5]Phoenix Scientific, St. Joseph, Missouri, USA.

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