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CHEMICAL ARTHRODESIS OF THE DISTAL TARSAL JOINTS USING SODIUM MONOIODOACETATE IN 104 HORSES

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Introduction

Degenerative joint disease of the tarsometatarsal (TMT) and distal intertarsal (DIT) joints is the most common cause of hind limb lameness in performance horses (Gabel, 1983; Sonnichsen, 1985; Wyn-Jones and May, 1986; Sullins, 2002). While medical management of degenerative joint disease of the distal tarsal joints often results in temporary improvement in lameness, approximately 50% of horses treated conservatively remain lame (Stashak, 1987; Bohanon, 1998, 1999). The aim of medical management is to ameliorate pain and allow continued exercise, promoting progressive cartilage deterioration and disruption of subchondral bone. The proposed end point of medical management is spontaneous ankylosis of affected joints and soundness; however, results are variable and convalescence prolonged (Stashak, 1987).

Drilling of the distal intertarsal joints is the current recommended technique for surgical arthrodesis (Edwards, 1982; McIlwraith and Turner, 1987; Dechant et al., 1999; Adkins et al., 2000). Complementary surgical techniques appear to be of little benefit over drilling alone (Wyn-Jones and May, 1986; Dechant et al., 1999; von Salis et al., 2000). Chemical arthrodesis using sodium monoiodoacetate (MIA) has been described as an alternative to surgery and has been shown to produce radiographic evidence of ankylosis but variable degrees of soundness (Bohanon et al., 1991; Bohanon, 1995a,b; Bohanon, 1998; Schramme et al., 1998). In two studies, soundness and evidence of radiographic fusion were reported in 22% (5/23) and 93% (27/29), and 92% (21/23) and 97% (28/29) of horses, respectively, 12 months after MIA injection (Bohanon, 1995a,b; Schramme et al., 1998). However, comprehensive studies, detailed description of technique, and complications associated with this procedure are not presently available.

The purpose of this study is to report the technique used, outcome, and complications of chemical arthrodesis of the distal intertarsal joints in 104 horses with degenerative joint disease of the TMT and/or DIT joints using MIA.

Materials and Methods

Horses included in the study were presented or referred to the University Veterinary Centre for lameness evaluation, poor performance, or chemical fusion of the distal

intertarsal joints based on examination and diagnosis by the referring veterinarian. A complete history was obtained from the owners. All horses underwent a lameness examination, including flexion tests and, if considered necessary to confirm the diagnosis, intra-articular anesthesia of the DIT and TMT joints. Lameness grade was recorded at admission and subsequent examinations using a standard grading system (Pasquini et al., 1995). All horses underwent radiographic examination of the TMT and DIT joints. A diagnosis of degenerative joint disease of one or more of the distal tarsal joints was made based on the history, lameness examination, and radiographic findings consistent with degenerative joint disease (Butler et al., 2000). Horses were included in the study if owners elected to proceed with arthrodesis using MIA in preference to other treatment options.

Sodium monoiodoacetate (Sigma-Aldrich, Castle Hill, Aust.) was prepared as a 100 or 200 mg/ml solution and sterilized by passing through a 0.2-μm filter as previously recommended (Bohanon, 1998). All solutions were prepared and used on the same day. Phenylbutazone (4.4 mg/kg, IV) was administered prior to chemical arthrodesis and all horses were sedated with detomidine hydrochloride (0.01 mg/kg, IV) and butorphanol tartrate IV (0.01 mg/kg, IV). Additional sedative was administered if required. The DIT and TMT on both limbs were injected at the same time irrespective of clinical and radiographic findings.

Tarsal joint injections were performed under aseptic conditions using a standard technique (Sack and Orsini, 1981; Kraus-Hansen et al., 1992). Contrast arthrography of the DIT joints was attempted in all horses. A 23-gauge, 2.5-cm needle was inserted into the DIT joints and 1 to 2 ml of iohexol (Omnipaque® 300 mg/Iml; Nycomed Pty Ltd, Aust.) was injected until resistance was encountered. The needles were capped and standard dorsopalmar and lateromedial radiographic views obtained. Radiographs were examined for correct needle placement. Radiographs were also examined for any evidence of communication between the DIT and the PIT (proximal intertarsal) joint, tarsocrural joint, or tarsal sheath (Bohanon, 1994). In horses where there was no suspicion of communication, needles were uncapped and the iohexol and any remaining joint fluid was aspirated. MIA was then injected through the same needle. The injection was stopped when there was resistance. The needle was then removed and digital pressure applied over the injection site. A maximum of 2 ml of MIA was injected into each joint. Contrast arthrography of the TMT joints was not performed. Needle placement in the TMT joints was confirmed by aspiration of joint fluid and low injection pressure. If there was any question about correct placement of the needle into any joint, the procedure was not performed on that joint. A second attempt was made 48 hours later or the injection was not performed.

Horses were monitored during the first 6 hours after injection for signs of pain. Each horse was assigned a comfort score (CS) of 0-4 (Table 1) (Johnson et al., 1993; Raekallio et al., 1997). Additional analgesia was provided using detomidine hydrochloride IV (0.01 mg/kg) and butorphanol tartrate IV (0.01 mg/

kg) if required. Phenylbutazone (4.4 mg/kg, PO, every 12 hours) was continued for 24 hours, and then the dose was reduced (2.2 mg/kg, PO, every 12 hours) for 10 to 14 days. Horses were allowed free exercise for the first 7 days. A graded exercise program was commenced after 7 days and incrementally increased to 30 to 45 minutes walking and trotting per day over the first 3 months and increasing to full work by 6 months post injection. When possible, a lameness evaluation including flexion tests and a radiographic examination was performed at 3, 6, 12, and 24 months.

Results

A total of 104 horses met the criteria for inclusion in the study. There were 27 warmbloods, 24 Thoroughbreds, 19 Quarter Horses, 7 Arabians, 19 Standardbreds, 5 Australian Stockhorses, 2 Andalusians, and 1 pony. Forty-four horses were used for dressage, 21 for racing (3 Thoroughbreds and 18 Standardbreds), 3 for endurance, 19 for western performance, 2 for showing, 8 for jumping, and 7 for pleasure riding. The mean age of treated horses was 7.2 years (range 2 to 17 years). Mean lameness grade on presentation was 2.9 out of 5 (range 1 to 4). Intra-articular anesthesia of all four distal tarsal joints was performed in 61 (60%) horses.

A total of 401 joints were injected with MIA. One hundred and ninety-five positive contrast arthrograms were successfully performed. In 12 horses (11.5%) communication was identified between DIT and TMT joints in one or both legs. No communication was identified between DIT joints and the tarsal sheath, PIT joint, or tarsocrural joint. The mean dose of MIA injected per joint was 192 mg (range 50-400 mg). The mean dose of MIA injected per DIT and TMT joint was 144 mg and 238 mg (range 50-400 mg), respectively.

The CS for each horse is recorded in Table 1. Horses assigned CS of 1 or 0 were treated with detomidine hydrochloride IV (0.01 mg/kg) and butorphanol tartrate IV (0.01 mg/kg) 4-6 hours after MIA injections. Five horses required only one treatment, and two horses required an additional injection 1-2 hours following the first. The mean MIA dose per joint in these 7 horses was 250 mg compared with a mean dose per joint of 187 mg in all other horses. Post-injection complications included transient, diffuse peri-articular swelling (57 horses), persistent peri-articular swelling and lameness (1 horse), focal temporary hair loss at injection site (2 horses), skin sloughing alone (2 horses), and skin sloughing and septic arthritis (4 horses). Six horses had focal swelling at one or more injection sites that resolved within 6 months of treatment. Three horses were euthanized, two due to septic arthritis of the DIT and one due to persistent peri-articular swelling and lameness. Two horses with septic arthritis survived. One is paddock sound, and the other is being ridden but not used for competition.

Table 1. The comfort scores used for assessing post-injection pain in horses undergoing chemical arthrodesis of the distal hock joints using MIA.

Score	*Description*	*Observations*	*No. of horses*
4	No discomfort	Normal. Bright, alert, and responsive. Eating normally. No tachypnea or sweating. Lameness grade 0-1. Heart rate = 40 bpm.	27
3	Mild discomfort	Bright, alert, and responsive. Eating normally. No tachypnea or sweating. Shifting weight on hind limbs. Lameness grade 2-3. Heart rate 41-60 bpm.	64
2	Moderate discomfort	Reduced appetite. Slight tachypnea and sweating. Lifting hind limbs. Lameness grade 3. Heart rate 41-60 bpm.	6
1	Considerable discomfort	Not eating. Moderate tachypnea and sweating. Pawing at ground. Lifting hind limbs. Lameness grade 4. Heart rate > 60 bpm.	5
0	Marked discomfort	Pawing at ground. Profuse sweating and tachypnea. Intermittently recumbent. Lameness grade 4. Heart rate > 80 bpm.	2

Where possible horses were radiographed and examined for lameness 3, 6, 12, and 24 months after treatment (Table 2). Twelve and 24 months following injection, 82% and 85% of horses examined were sound, respectively. Twenty-one horses were <3 months post treatment and had not been re-examined. A total of 12 horses were lost to follow-up. Twelve horses were ultimately retired due to lameness localized in another site, and three were euthanized for unrelated reasons.

Table 2. Results of lameness examination and radiographic evaluation of horses 3, 6, 12, and 24 months after injection of TMT and DIT joints with MIA.

		Lameness evaluation results		*No. of horses*
Time post MIA (months)	*No. of horses examined*	*No. of sound horses (%)*	*Mean lameness grade (No. of horses)*	*with radiographic evidence of fusion ≥1 joint (%)*
3	57	0	2.3 (57/57)	4/55 (8%)
6	55	14/55 (25%)	1.5 (41/55)	24/38 (63%)
12	50	41/50 (82%)	1.5 (9/50)	29/34 (87%)
24	34	29/34 (85%)	1.5 (5/34)	18/18 (100%)
>24	10	10/10 (100%)	-	10/10 (100%)

Thirteen DIT joints in 12 horses were not treated due to difficulty in confirming needle location, pre-existing fusion of joint space, or inconclusive contrast

arthrograms. Radiographic evidence of ankylosis was evident in 4 of these horses 12 months after treatment. Three horses had progressive but incomplete radiographic evidence of ankylosis of the untreated joint at 6 months post treatment. Four horses were less than 3 months post treatment and had not been re-examined. One horse was lost to follow-up.

Owner satisfaction was recorded for 62 horses. Fifty-six owners (90%) were pleased with the outcome, and 6 owners (10%) were disappointed with the outcome.

Discussion

MIA causes an increase in intracellular concentration of adenosine triphosphate resulting in inhibition of glycolysis and cell death (Bohanon et al., 1991). It causes dose-dependant cartilage degeneration characterized by cartilage fibrillation, chondrocyte death, and glycosaminoglycan and proteoglycan depletion (Bohanon et al., 1991; Gustafson et al., 1992). MIA has been shown to produce reliable radiographic and histological ankylosis of the distal tarsal joints, and this technique for chemical arthrodesis has been recommended as an alternative to surgical techniques (Bohanon et al., 1991; Bohanon, 1995a,b; Bohanon, 1998, 1999). The results reported for soundness and evidence of radiographic evidence of ankylosis at 12 and 24 months in the study here compare favorably with previous reports (Bohanon et al., 1991; Bohanon, 1995a,b; Bohanon, 1998). In a recent study, in contrast, only 18% (7/38) and 22% (5/23) of horses were sound 6 and 12 months, respectively, after intra-articular injection of MIA into the distal tarsal joints (Schramme et al., 1998). Lameness was present despite a similar percentage of horses with radiographic evidence of ankylosis as reported in the present and previous studies (Bohanon et al., 1991; Bohanon, 1995a,b; Schramme et al., 1998). There was no explanation offered for the poor outcome in this study (Schramme et al., 1998). However, possible differences between studies may reflect differences in injection technique, in exercise regimen after injection, or differences in techniques for lameness evaluation and grading.

Exercise has been advocated to increase the rate of fusion after surgical and chemical arthrodesis (McIlwraith and Turner, 1987; Bohanon et al., 1991; Sammut and Kannegieter, 1995). Bohanon et al. (1998) recommended up to 1 hour of exercise per day, 6 days per week beginning 2 days after MIA treatment. In the present study, graded exercise commenced 7 days after injection, increasing to 30 to 45 minutes walking and trotting per day by 3 months, and increasing to full work by 6 months after treatment. Even though no horses were sound at 3 months and the incidence of radiographic ankylosis was low, most owners reported that horses were willing to work during this period. Previous reports have found MIA to cause acute synovial inflammation lasting for approximately 3 weeks after injection (Bohanon et al., 1991). Synovial inflammation may lead to disruption of synovial neural function and temporary analgesia, which may account for the improvement in demeanor and lameness (Bohanon, 1995a,b). Typically from 3 to

6 months post MIA, the degree of lameness is reportedly variable and may be related to mechanical failure of deposited woven or lamellar bone across the joint as the joints try to ankylose (Bohanon et al., 1991). Progressive ankylosis is associated with increased joint stability and subsequent resolution of lameness once approximately 70% of the articular surface is fused (Bohanon et al., 1991). In the present study, despite similar results for 12 and 24 months after injection, at 3 and 6 months soundness and evidence of radiographic ankylosis were comparably lower than reported in other studies (Bohanon et al., 1991; Bohanon, 1995a,b). This difference may reflect differences in the exercise programs following injection. While it would appear ankylosis and soundness can be achieved as early as 6 months post MIA treatment with more intensive exercise programs (Bohanon et al., 1991), we suggest progressive ankylosis may occur beyond 6 months such that maximal soundness may not be achieved until 12 or 24 months post MIA treatment in some horses.

Acute pain is reported to occur in approximately 30% of horses following drilling of the distal tarsal joints and is thought to be related to joint instability, surgical technique, and diameter of drill bit (Adams, 1970; Gabel, 1978; von Salis et al., 2000). Anecdotal reports of severe post-injection pain have contributed to a reluctance in using MIA for chemical arthrodesis of the distal tarsal joints. However, in the present study only 6.7% (7/104) of horses experienced severe discomfort (CS of 1 or 0). This discomfort was adequately managed with the use of additional analgesic drugs. The mean MIA dose used per joint in these 7 horses was 250 mg with 4 horses receiving a mean dose ≥ 300 mg. This was compared to a mean dose per joint of 187 mg in horses with a CS of 2, 3, or 4 suggesting a dose-related pain response.

Some authors have suggested the pain is associated with irritant effects on soft tissue, synovium, and plantar metatarsal nerves (Bohanon et al., 1991; Sammut and Kannegieter, 1995); however, to date the effects of MIA on soft tissue have not been investigated. It is reasonable to assume that in high enough concentrations MIA is detrimental to soft tissue viability. Peri-articular leakage, soft tissue inflammation, and subsequent pain is likely to be related to injection volume, the final pressure within the joint, gauge of needle, and the number of needle punctures required to correctly place the needle in the joint.

Other complications reported with the use of MIA include skin and soft tissue necrosis, septic arthritis, serous exudation at injection site, persistent lameness, and peri-articular swelling (Bohanon, 1995a,b; Schramme et al., 1998). In the present study, complications included transient peri-articular swelling (57 horses), persistent peri-articular swelling and lameness (1 horse), focal temporary hair loss at injection site (2 horses), skin sloughing alone (2 horses), and skin sloughing and septic arthritis (4 horses). These complications were most likely related to peri-articular leakage of MIA.

Previous investigations reported that intra-articular doses of 0.16 mg/kg (80 mg of MIA/500-kg horse) did not induce significant subchondral bone damage;

however, it is possible that at higher concentrations subchondral bone necrosis will occur (Gustafson et al., 1992). In all 4 horses that developed septic arthritis, the DIT joint was involved. Injection of the DIT joints in some horses is more difficult due to marked narrowing of the medial joint space, partial ankylosis, or medial osteophytosis. Repeated injection attempts combined with higher concentrations of MIA to compensate for lower volumes of injection may have contributed to soft tissue necrosis, septic arthritis, subchondral necrosis, and joint instability in some horses.

Based on our experience, we recommend using 23-gauge needles, a maximum volume of 2 mL of 100 mg/ml MIA, and stopping injection when resistance is felt on the syringe plunger. We suggest pain can be managed by using suitable analgesics administered prior to and following chemical arthrodesis and using the recommended technique to minimize injection-related complications.

In contrast to previous studies, communication occurred between the DIT and TMT joints in only 11.5% (12/104) of horses, and no communication was identified between the DIT joint and PIT joint or tarsal canal (Kraus-Hansen et al., 1992; Dyson and Romero, 1993; Bohanon, 1994). In a previous report, degenerative joint disease of the PIT joint is reported to have developed in 10% (4/39) of horses between 1 to 4 years after MIA treatment (Bohanon, 1998). Because no arthrograms were performed in this study, it was presumed that MIA had leaked into the PIT joint. To date no horses in the present study have developed degenerative joint disease of the PIT or tarsocrural joints. However, differences in injection volume and techniques make direct comparisons between studies difficult. Correct needle placement, use of radiographic control when injecting the DIT joint, and optimizing injection volume, in the absence of complications associated with joint injection, will minimize inadvertent leakage into synovial structures (Bohanon, 1994).

Numerous techniques have been described for surgical arthrodesis with success rates varying from 57-80% (Adams, 1970; Mackay and Liddell, 1972; Edwards, 1982; Barber, 1984; Sonnichsen, 1985; Wyn-Jones and May, 1986; McIlwraith and Turner, 1987; Archer et al., 1989; Dechant et al., 1999; Adkins et al., 2000; Hague et al., 2000; von Salis et al., 2000). Surgical techniques require general anesthesia and specialized instrumentation, and are associated with a variety of complications including sepsis, postoperative pain, and prolonged convalescence (Edwards, 1982; Barber, 1984; McIlwraith and Turner, 1987; Archer et al., 1989; Bohanon, 1998; von Salis et al., 2000). Chemical arthrodesis using MIA can be performed under standing sedation with minimal equipment. This technique appears to provide a more reliable outcome than surgical techniques with a low incidence of complications. PIT joint involvement or synovial communication between the tarsocrural joint, PIT joint, or tarsal sheath with the distal tarsal joints preclude the use of MIA.

The present study demonstrates that MIA is an effective treatment for degenerative joint disease of the distal tarsal joints and results are comparable to

those achieved by surgical arthrodesis. Resolution of lameness may take up to 12 months and occasionally longer. Soundness can be achieved in 82% and 85% of horses at 12 and 24 months, respectively. Significant complications are uncommon but may occur and are likely related to peri-articular injection, leakage of MIA, or use of higher concentrations or volumes. Post-injection pain can be marked in a small number of horses but is transient and can be managed effectively with analgesic drugs.

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