Use of intra-articular administration of ethyl alcohol for arthrodesis of the tarsometatarsal joint in healthy horses

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Objective—To evaluate the efficacy and safety of intra-articular administration of ethyl alcohol for arthrodesis of tarsometatarsal joints in horses.

Animals—8 healthy female horses without lameness or radiographic evidence of tarsal joint osteoarthritis.

Procedure—in each horse, 1 tarsometatarsal joint was treated with 4 mL of 70% ethyl alcohol and the opposite joint was treated with 4 mL of 95% ethyl alcohol. Lameness examinations were performed daily for 2 weeks, followed by monthly evaluations for the duration of the 12-month study. Radiographic evaluations of both tarsi were performed 1 month after injection and every 3 months thereafter. Gross and histologic examinations of the tarsi were undertaken at completion of the study.

Results—Horses had minimal to no lameness associated with the treatments. Radiography revealed that 8 of 16 joints were fused by 4 months after treatment, with significantly more joints fused in the 70% ethyl alcohol group. Fifteen of 16 joints were considered fused at postmortem examination at 12 months. Gross and histologic examinations revealed foci of dense mature osteonal bone spanning the joint spaces. Bony fusion appeared to be concentrated on the dorsolateral, centrolateral, and plantarolateral aspects of the joints. Significant differences were not detected between treatment groups for lameness or pathologic findings.

Conclusions and Clinical Relevance—Administration of ethyl alcohol into the tarsometatarsal joint of healthy horses appeared to facilitate arthrodesis of the joint in a pain-free manner. Results warrant further investigation into the potential use of ethyl alcohol in horses clinically affected with osteoarthritis of the tarsometatarsal and distal intertarsal joints. (Am J Vet Res 2006;67:850–857)

Osteoarthritis of the distal intertarsal and tarsometatarsal joints (bone spavin) is one of the most common causes of hind limb lameness in horses. A large proportion of horses with performance-limiting osteoarthritis of the distal intertarsal and tarsometatarsal joints can maintain athletic careers with the aid of medical treatment, surgical intervention, or both. The most common treatments for management of pain and lameness associated with the disease are systemic administration of nonsteroidal anti-inflammatory drugs, such as phenylbutazone, and intra-articular administration of corticosteroids. Adverse effects of chronic administration of nonsteroidal anti-inflammatory drugs and reduced efficacy associated with prolonged administration may be problematic. Other medical treatments reported to manage the pain and lameness include systemic or intra-articular administration of hyaluronate, oral administration of glucosamine, and corrective shoeing.

Fusion of the arthritic joints allows the horse to function in a pain-free manner. Facilitated joint fusion or arthrodesis can be attained by either chemical destruction of the articular cartilage and chondrocytes or mechanical obliteration of the joint via surgical intervention. Intra-articular drilling of the joint spaces is the most widely used means of mechanical destruction of the articular cartilage and subchondral bone. The drill tracts eventually heal with a bridging callus across the joints and stabilize the joint in a manner similar to spot welding of metal. A recent clinical report indicates that 59% of treated horses returned to their intended athletic function. Disadvantages of surgical arthrodesis include expense and prolonged convalescence, which ranges from 4 to 12 months.

Monoiodoacetate is an inhibitor of chondrocyte metabolism that, when injected intra-articularly, induces chondrocyte death. The premise of this treatment is that the death of chondrocytes precludes the maintenance of articular cartilage, which is mechanically disrupted as the horse continues to exercise on the abnormal cartilage. Attributes of this treatment that limit its widespread acceptance as a treatment for bone spavin include the apparent discomfort of the horse after treatment, progression of osteoarthritis in the proximal intertarsal joints, severe soft tissue necrosis that can occur with extra-articular injection, variable length of convalescence, and inconsistent outcome.

A recent clinical report of laser-assisted arthrodesis is encouraging; however, controlled studies are lacking, and recent research has questioned the efficacy of the diode laser to arthrodeses the tarsometatarsal and distal intertarsal joints. Hydrothermal chondrocyte necrosis is another potential treatment that has been described in an experimental model and may have actions similar to monoiodoacetate without some of the detrimental adverse effects.

An ideal treatment to facilitate arthrodesis of the tarsometatarsal and distal intertarsal joints in horses does not presently exist. Some qualities that would be considered optimal in a treatment for osteoarthritis of

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the distal intetarsal and tarsometatarsal joints include minimal invasiveness, effective necrosis of the chondrocytes and destruction of the articular cartilage matrix leading to arthrodesis of the joint, minimal to no discomfort for the horse during the treatment period, lack of serious consequences if inadvertently administered extra-articularly, and affordability. Ethyl alcohol is a colorless liquid that has been used in equine medicine primarily to attain prolonged blockage of nerve conduction of the palmar digital nerves or unscrupulously as a semipermanent block for nerves supplying the muscles of the tail. In human medicine, ethyl alcohol is mainly used to induce long-term sensory blockage (neurolysis) for relief of chronic, unresponsive pain in cancer patients as a treatment for spasticity, as a vascular sclerotherapy, and for ablation of renal cysts.

Properties of ethyl alcohol that contribute to clinical success are nonselective protein denaturation and cell protoplasm precipitation and dehydration. The drug achieves a combination of neurolysis and tissue destruction at the drug-tissue interface. Ethyl alcohol can be affordably placed into the joint through a hypodermic needle, and because of its neurolytic and nonselective protein-destructive properties, it has the potential to block sensory innervation to the joint while disrupting the cartilaginous matrix, causing necrosis of chondrocytes and hastening arthrodesis. The purpose of the study reported here was to evaluate the efficacy and safety of intra-articular administration of ethyl alcohol for arthrodesis of the tarsometatarsal joint in horses. The hypothesis for the study was that intra-articular administration of ethyl alcohol would result in joint fusion in a pain-free manner with minimal adverse effects.

Materials and Methods
All procedures involving the use of horses were approved by the University Committee on Animal Care and Supply at the University of Saskatchewan and were conducted in accordance with guidelines established by the Canadian Council on Animal Care. A pilot study was performed to assess the feasibility of using ethyl alcohol as a treatment for lameness in horses. Four 3- to 4-year-old mixed-breed horses were evaluated for lameness of the hind limbs and screened for radiographic evidence of osteoarthritis in the tarsometatarsal or distal intertarsal joints. Horses were housed in a large outdoor paddock with free access to water and brome-alfalfa hay. X-rays were obtained of the tarsometatarsal joints, which were used to determine the presence or absence of osteoarthritis.

Pilot study
Four 3- to 4-year-old female Quarter Horses were evaluated for lameness of the hind limbs and screened for radiographic evidence of osteoarthritis of the distal intertarsal and tarsometatarsal joints bilaterally. Lameness examination consisted of observation of the horses trotting in a straight line on a hard surface in hand. Radiographic evaluation of the tarsos was performed in the sagittal plane. Marginal osteophytes of the tarsometatarsal joint were recorded when encountered. Horses were sedated with a combination of detomidine (10 μg/kg, IV) and butorphanol (0.01 mg/kg, IV). Radiography of both tarsi was performed and included the 4 standard views, as described.

Ethyl alcohol injection—Horses were randomly assigned to receive either 20% (2 horses) or 70% (2) ethyl alcohol in 1 tarsometatarsal joint. One tarsometatarsal joint of each horse was randomly assigned as a treatment joint, and the opposite tarsometatarsal joint served as an untreated control. The horses were sedated with xylazine (1.0 mg/kg, IV), and short-term anesthesia was induced with a bolus of ketamine hydrochloride (2.2 mg/kg, IV). Horses were positioned in lateral recumbency with the treatment joint uppermost, and the region of both tarsometatarsal joints was clipped and aseptically prepared for intra-articular injection. The treated joints received an injection (4 mL) with a 19-gauge needle placed over the head of the fourth metatarsal bone, as described. Entry into the joint was considered successful if synovial fluid was evident in the hub of the needle or injection of the ethyl alcohol was without resistance. The 20% or 70% solutions were injected into the treated joint by a clinician unaware of the alcohol concentration. The horses recovered from anesthesia unassisted, received a single dose of phenylbutazone (2.2 mg/kg, PO), and were returned to an outdoor paddock.

Clinical and radiographic evaluations—Horses were assessed daily for evidence of lameness according to the American Association of Equine Practitioners lameness scale. Daily examination also focused on any reaction in the area of the injection site of the tarsometatarsal joint, including swelling, hair discoloration or loss, and localized cellulitis. Radiographic views, as described, were obtained 1 month after the intra-articular injections.

Postmortem examination—Horses were euthanized by use of a lethal dose of sodium pentobarbital administered IV, 1 month after injection of ethyl alcohol. Gross examination of all tarsi was undertaken by a pathologist (ALA), who was unaware of which joint had been treated and focused on the appearance of the articular cartilage, compared with the opposite tarsometatarsal joint. After the soft tissue was removed from the tarsi, they were sectioned into 5-mm slices in the sagittal plane. Marginal osteophytes of the tarsometatarsal joint were recorded when encountered. The tarsi were fixed in neutral buffered 10% formalin, decalcified in 20% formic acid, and processed routinely. Histologic examinations were performed on the dorsal aspect of the joint capsule along with the lateral and medial aspect of the proximal articular surface of the third metatarsal bone and the distal articular surface of the third tarsal bone. The joint capsule was stained with H&E and subjectively evaluated for synovial inflammation and fibrous tissue infiltration. Articular surfaces were stained with H&E and safranin O-fast green to detect degeneration of the articular cartilage and chondrocyte necrosis.

Twelve-month study
Horses—Eight 3- to 4-year-old female Quarter Horses were evaluated for clinical evidence of lameness; evaluation included flexion of the upper portion of the hind limb. The horses were sedated with a combination of detomidine (10 μg/kg, IV) and butorphanol (0.01 mg/kg, IV). Radiography of both tarsi was performed and included the 4 standard views, as described. Horses were included in the study if there was no detectable lameness or any radiographic indication of osteoarthritis in the tarsometatarsal or distal intertarsal joints. Horses were housed in a large outdoor paddock (60 X 40 m) with free access to water and brome-alfalfa hay.

Horses were vaccinated once against eastern equine encephalitis virus, western equine encephalitis virus, and tetanus and twice against West Nile virus, 4 weeks apart. At the termination of the project (12 months), the horses were euthanized with an IV bolus injection of sodium pentobarbital.

Ethyl alcohol injection—Horses received injections in both tarsometatarsal joints; 1 joint received 70% ethyl alcohol (4 mL), and the opposite joint received 95% ethyl alcohol (4 mL) via random assignment. The horses were anesthetized and prepared as described.
each concentration of ethyl alcohol was injected SC over the middle third of the third metacarpal bone between the common digital extensor tendon and the lateral digital extensor tendon of the ipsilateral forelimb. This was performed to assess the effect of ethyl alcohol on extra-articular tissues. The clinician performing the injections was unaware of the concentration of ethyl alcohol used. Recovery from anesthesia was unassisted, and horses received a single dose of phenylbutazone (2.2 mg/kg, PO) prior to being turned out in the paddock.

**Clinical evaluation**—Horses were evaluated for attitude, appetite, and lameness daily for 2 weeks by trotting the horses on a firm surface in hand and grading the lameness, as described. Lameness examinations were all performed by the same individual (RWS), who was unaware of the treatment groups. Radiographs were subjectively graded on a scale from 0 to 9 for osteophytes, subchondral sclerosis or lysis, joint space narrowing, and evidence of bony fusion of the treated joints (0 = no change, 1 = mild osteophytes, 2 = moderate osteophytes, 3 = subchondral sclerosis or lysis, 4 = moderate joint space narrowing, 5 = marked joint space narrowing, 6 = periarticular bone bridging, 7 = fourth metatarsal-fourth tarsal bone fusion, 8 = third metatarsal–third tarsal bone fusion, and 9 = >30% bony fusion of the tarsometatarsal joint). For statistical comparisons at each evaluation period, each joint received a numeric score that consisted of the highest score assigned at the examination period. The joint was considered fused if the radiographic series included a numeric grade of 6, 7, 8, or 9.

**Gross evaluation**—Gross examination of both tarsi was performed 1 month after the tarsometatarsal joint injections and then every 3 months until the completion of the study at 12 months. All radiographs were evaluated by the same clinician (DGW), who was unaware of the treatment groups. Radiographs were subjectively graded on a scale from 0 to 9 for osteophytes, subchondral sclerosis or lysis, joint space narrowing, and evidence of bony fusion of the treated joints (0 = no change, 1 = mild osteophytes, 2 = moderate osteophytes, 3 = subchondral sclerosis or lysis, 4 = moderate joint space narrowing, 5 = marked joint space narrowing, 6 = periarticular bone bridging, 7 = fourth metatarsal-fourth tarsal bone fusion, 8 = third metatarsal–third tarsal bone fusion, and 9 = >30% bony fusion of the tarsometatarsal joint). For statistical comparisons at each evaluation period, each joint received a numeric score that consisted of the highest score assigned at the examination period. The joint was considered fused if the radiographic series included a numeric grade of 6, 7, 8, or 9.

**Histologic evaluation**—The sagittal slab sections were photographed and radiographed prior to histologic examination.

**Statistical analysis**—All data were analyzed with statistical software for personal computers. Independent variables for all comparisons were the 2 treatment groups (70% or 93% ethyl alcohol). Nonparametric analyses were used for comparison of groups because the dependent variables in all data sets were classified as ordinal data because of the ranked nature of the outcomes. Dependent variables included the subjective classification of lameness, radiographic scores, radiographic evidence of fusion, and histologic evidence of fusion. For comparison of lameness, a McNemar symmetry test was used to evaluate the potential difference between the 2 groups during the initial week after treatment and again during the monthly examinations. To evaluate the radiographic changes prior to and after treatments, a Wilcoxon signed rank test was used to compare the assigned scores. A Fisher exact test was used to compare histologic evidence of bony fusion in the joints between groups. Differences were considered significant at \( P \leq 0.05 \).

**Results**

**Pilot study**

No horses in the pilot study had radiographic evidence of osteoarthritis in the tarsometatarsal or distal intertarsal joints or lameness prior to the onset of the study. Injections of the tarsal joints were performed without complications, and all joints received the entire ethanol volume without excessive resistance to administration.

**Clinical and radiographic evaluations**—No horses had lameness, skin necrosis, or hair loss associated with the injection sites during the 1-month evaluation period. Minimal local swelling was evident at the site of injection in all horses, and no subjective difference was discerned between horses that received 20% versus 70% ethyl alcohol. Radiographic evaluation of the treated tarsometatarsal joints at 1 month revealed minimal periarticular osteophytes associated with the proximalateral aspect of the third metatarsal bone, minimal joint space narrowing, and mild subchondral sclerosis in the joints treated with 70% ethyl alcohol. There were no radiographic changes in the joints treated with 20% ethyl alcohol or in the opposite control joints, compared with the initial radiographs.

**Postmortem examination**—In the 2 horses treated with 20% ethyl alcohol, gross pathologic changes to the articular surface of the treated joints were minimal and consisted of thin, dull, gray cartilage. Results of histologic examination were similar to gross findings, with only mild irregularities such as flattening of the surface of the articular cartilage and a mild decrease in the staining of the cartilage matrix, compared with the control joints. Gross examination of the joints treated with 70% ethyl alcohol revealed pronounced changes including markedly thin, dull, gray cartilage, compared with the control joints. The joints were also surrounded by moderate osteophytosis associated with the dorsal and dorsolateral aspects of the proximal articular surface of the third metatarsal bone and the distal aspect of the third tarsal bone. Histologic evaluation of the joint capsule revealed synovium devoid of villi, with moderate mononuclear cell infiltration and areas of mineralized fibrocartilage. Examination of the articular cartilage revealed irregular, tattered cartilage with diffuse granularity and hypererosinophilia of the superficial layers. In addition, chondrocyte necrosis was evident in the superficial and middle layers of the articular cartilage as well as osteophyte formation at the dorsal joint margins.

**Twelve-month study**

**Horses**—All 8 horses were free of lameness and...
radiographic evidence of osteoarthritis in the tarsometatarsal and distal intertarsal joints prior to the onset of the study. Injections into the tarsometatarsal joints were without complications in 15 of 16 joints, as indicated by synovial fluid within the hub of the needle prior to injection of alcohol. In 1 joint, the clinician was unable to confirm placement of the hypodermic needle within the joint because synovial fluid was not obtained; however, excessive injection pressure was not required, and this was interpreted as an indication of intra-articular placement of the ethyl alcohol. Injection of ethyl alcohol was easily achieved in all horses at both the intra-articular and SC sites.

Clinical evaluation—No horses had signs of discomfort after intra-articular injection, as indicated by a normal appetite and attitude throughout the study. The presence of ethyl alcohol in SC locations caused mild swelling in all horses immediately after the injection and persisted for 24 hours in 13 of the 16 sites before subsiding. In 2 sites (1 for each concentration) of 2 horses, moderate localized edema was observed for 3 to 4 days after injection and then slowly dissipated during the next 12 days. At no time were any of the swellings on the dorsal aspect of the metatarsal bones associated with signs of pain when palpated or manipulated. The 16th site (70% ethyl alcohol) was markedly swollen and yielded signs of pain when touched; more generalized involvement of the limb was evident within 12 hours of injection. The swelling became more localized, and signs of pain gradually subsided during the next 12 days, at which point the swelling was considered minimal. The skin overlying the injection sites remained grossly normal for the duration of the study.

There were no discernable swellings at the tarsal injection sites for the first 2 weeks after injection. A gradual but mild enlargement near the head of the fourth metatarsal bones was subjectively observed in most horses over time. The swellings appeared to increase in size during the first 4 months after injection and reached a maximum dimension of 5 mm in height and 2 cm in diameter. The enlargements gradually receded and were difficult to detect by the end of the study. There were no changes in the appearance of the skin, such as hair loss or discoloration.

Lameness evaluation—In the first week after treatment, the horses had minimal lameness and no significant difference in lameness was observed between the 70% and 93% ethyl alcohol treatments (P = 0.168).

Only 2 of the 16 treated limbs (both treated with 70% ethyl alcohol) had any lameness during the initial week. The lameness in 1 horse was grade III on day 2 and resolved by day 7. In the other horse, a grade I lameness was observed on days 2 and 3. At no time did flexion of the upper portion of the hindlimb exacerbate the lameness. Mild lameness (grades 1 to II) was observed in 3 limbs (1 treated with 95% ethyl alcohol and 2 treated with 70% ethyl alcohol) at 3 times during the monthly examinations; no significant difference was observed between treatment groups (P = 0.169). One limb had positive results of flexion of the upper portion of the limb during the 11-month examination; however, the horse was not lame prior to flexion.

Radiographic evaluation—Serial radiographic evaluation of the tarsi revealed progression toward joint fusion throughout the study period; the most severe change occurred between the 1- and 4-month evaluations (Table 1). For radiographic scores, a significant difference between ethyl alcohol concentration groups was detected only at the 4-month examination. For the proportion of tarsi considered fused via radiography, a significant difference between groups was also detected only at the 4-month examination (Table 2). The radiographic change initially appeared as mild osteoarthritis of the tarsometatarsal joint at 1 month, with rapid progression to dorsolateral bone bridging at 4 months (Figure 1), followed by gradual remodeling of the perarticcular bone, continued collapse of the joint space, and intra-articular fusion on the plantar aspect of the joint (Figure 2).

Gross pathologic findings—Fifteen of the 16 tarsometatarsal joints had similar gross pathologic changes with minimal variation in the degree of articular degeneration and bony fusion. There was marked, generalized narrowing and extensive, multifocal bony bridging across the joint space between the third tarsal and third metatarsal bones. In addition, the articular cartilage in areas without bony fusion was thin and discolored. Bony fusion was also observed between the third tarsal and fourth metatarsal bones as well as across the joint space between the fourth tarsal and fourth metatarsal bones (Figure 3). The bony fusion appeared to be more prominent in the dorsolateral, central (around the interosseous ligament), and plantarolateral aspect of the tarsometatarsal joints. Radiography of the sagittal slab sections also confirmed bony bridging that was concentrated on the dorsolateral and plantarolateral aspect of the tarsometatarsal joints. Focal lack of joint space was evident between the

<table>
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<th>Group</th>
<th>Month</th>
<th>0</th>
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<th>4</th>
<th>7</th>
<th>10</th>
<th>12</th>
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<td>70%</td>
<td>0</td>
<td>1.0 (0–4)*</td>
<td>6.0 (1–8)**</td>
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<td>7.0 (4–9)*</td>
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<tr>
<td>95%</td>
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<td>1.0 (0–4)*</td>
<td>4.0 (1–6)*</td>
<td>6.5 (1–8)*</td>
<td>7.0 (1–9)*</td>
<td>7.0 (0–9)*</td>
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<tr>
<td>Overall</td>
<td>0</td>
<td>1.0 (0–4)*</td>
<td>5.5 (1–8)*</td>
<td>7.0 (1–9)*</td>
<td>7.0 (1–9)*</td>
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*Significantly (P ≤ 0.05) different from values for time 0. †Significantly (P ≤ 0.05) different from corresponding value in 95% ethyl alcohol group. **Within row, significantly (P ≤ 0.05) different from previous value.
third tarsal and third metatarsal bones and between the fourth tarsal bone and the underlying third and fourth metatarsal bones (Figure 4).

**Histopathologic findings**—Similar to gross findings, all but one of the tarsometatarsal joints had bone bridging the joint space (Figure 5). Typical findings were that a large amount of the third tarsal–third metatarsal joint space was replaced by dense mature osteonal bone with foci of woven interstitial bone. Areas without bony fusion consisted of articular cartilage that was thin, diffusely necrotic, and frayed. Fusion appeared to be generalized on the plantar lateral aspect and focally evident on the dorsolateral and centrolateral aspects of the joint. In addition, the interosseous tarsometatarsal ligaments were replaced with fibrocartilage and bone. In the joint without evidence of fusion (93% ethyl alcohol group), the articular cartilage appeared normal and no abnormalities were evident.

<table>
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<tr>
<th>Month</th>
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<th>Group 7</th>
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See Table 1 for key.

Joint spaces between the third tarsal bone, fourth tarsal bone, and metatarsal bones were almost completely absent and replaced with dense mature bone. Any...
remaining cartilage was necrotic and had chondrone formation. All bridged tarsometatarsal joints (70% and 95% groups) appeared to have similar changes; the lack of objective criteria precluded the comparison of degree of fusion between groups. There was no significant difference between the 2 treatment groups regarding bony bridging of the tarsometatarsal joint ($P = 0.999$).

**Discussion**

The purpose of this study was to develop a minimally invasive treatment for bone spavin that is effective and affordable, has a short convalescence period, and minimizes the discomfort associated with the disease while fusion is occurring. Results of this study indicated that intra-articular administration of ethyl alcohol warrants further investigation in the clinical setting as a treatment for naturally occurring osteoarthritis in the tarsus of horses.

The pilot project was designed to evaluate the short-term effects of administration of ethyl alcohol in a small number of horses, which minimized the risk of unnecessary pain and discomfort in a large number of horses. The neurolytic and destructive properties of ethyl alcohol made the treatment appealing, and the authors were unaware of any other reports in the scientific literature on intra-articular administration of this chemical in horses. The ethyl alcohol concentrations of 20% and 70% were initially chosen because at concentrations $> 10\%$, ethyl alcohol denatures proteins and injures cells in a nonselective manner, whereas at concentrations of 45% to 75%, painful muscle necrosis has been reported in humans. Neither concentration appeared to have adverse effects in the horses with regard to lameness or injection lesions. Seventy percent ethyl alcohol yielded much more promise in degradation of the tarsometatarsal joints, which was the reason for inclusion of this concentration in the long-term study. Ninety-five percent ethyl alcohol was also evaluated because of results of the pilot project, which suggested that higher concentrations of ethyl alcohol might be more effective in chemical destruction of the articular surface (ie, 70% ethyl alcohol was superior to 20% ethyl alcohol).

Minimal local irritation was observed in areas of the injections (SC and intra-articular), with no long-term adverse outcomes such as skin necrosis or hair discoloration. This decreases concern over inadvertent periarticular injections, which can be disastrous after treatment with monoiodoacetate. Subcutaneous injection of 4 mL of ethyl alcohol over the proximal portion of the metatarsal bones was performed to ensure that unacceptable cosmetic results would not occur if the injection was inadvertently made outside the joint. Only 1 of the 36 injection sites had more than mild localized cellulitis, and in the more severely affected site, there were no detrimental effects on cosmesis. Subtle swelling was associated with the tarsometatarsal injection sites, which peaked at 4 months after treatment and slowly receded and disappeared by completion of the study. The time line of the swelling was similar to that of the radiographic evidence of periarticular bone production, which also decreased over time.

Horses in both the pilot study and 12-month study had minimal lameness after treatment. Because only 2 limbs treated with 70% ethyl alcohol had lameness in the first week, it appeared that treatment caused minimal pain. The horse with grade III lameness on the second day after treatment was assumed to have a transient synovitis because lameness improved markedly during the next 4 days without intervention, at which time the horse was considered sound. Lameness in the other horses was sporadic and mild (< grade II). Although this study used horses without clinical joint disease, ethyl alcohol appeared to cause less pain, compared with studies that evaluated chemical, laser, or surgical treatments designed to fuse the distal intertarsal and tarsometatarsal joints in healthy horses. Although unknown at this time, ethyl alcohol's neurolytic properties may have been responsible for...
decreasing the discomfort in our research horses. Investigation into the mechanism of possible analgesic properties of intra-articular administration of ethyl alcohol is warranted. If treatment destroys the sensory innervation of the synovium, joint capsule, and subchondral bone, this may account for progressive fusion of the joint without associated lameness.

The minimal to absent lameness apparent after injection of ethyl alcohol into the tarsometatarsal joint suggests that no convalescent period would be required for treated horses. Although treatment was not evaluated in horses with clinical lameness, results of this study suggest that treatment via intra-articular administration of ethyl alcohol should not increase the discomfort of horses with osteoarthritis of the distal intertarsal and tarsometatarsal joints. This may allow owners to continue to use their horses competitively while treating the horse for osteoarthritis.

Serial radiographs of the tarsi revealed minimal change 1 month after treatment, followed by substantial progression to joint fusion. It appeared that 70% ethyl alcohol hastened the development of joint fusion, compared with 95% ethyl alcohol, as observed at 4 months. The final outcome, however, did not differ between groups. The radiographic progression suggested that a minimal amount of time was required for the ethyl alcohol to kill chondrocytes and disrupt the cartilage matrix, followed by rapid bony proliferation across and within the joint. Interestingly, the number of joints considered fused via radiography at 12 months (14/16) underestimated the true prevalence of joint fusion, as determined by postmortem examination (13/16). Radiographic evaluation of the equine tarsus is challenging, and assessing the degree of bony fusion is, at best, an estimation.

In all but 1 of the 16 tarsometatarsal joints, there was gross and histopathologic evidence of bony fusion. The joint that did not have evidence of fusion or any articular lesions was the joint in which no synovial fluid was obtained in the hub of the needle prior to injection of the ethyl alcohol; apparently, no ethyl alcohol was placed in the joint. Clinicians should be aware that ease of injection does not always indicate intra-articular administration of ethyl alcohol in a low-motion, small tarsal joint with as few confounding variables as possible. We postulate that in clinical cases, intra-articular injection of ethyl alcohol in the distal intertarsal joint should yield similar results.

The degree of bony fusion varied, albeit minimally, among the joints. The fact that most bony bridging consisted of mature osteonal bone suggested that fusion occurred early in the treatment period and the bone was remodeled during the remainder of the study. Typically, fusion occurred at the dorsolateral aspect of the joint between the third tarsal and third metatarsal bones; the centrolateral aspect of the joint; in and around the intrasoosseous ligament; along the plantar aspect of the joint between the third tarsal and third metatarsal bones; and along the plantarolateral aspect of the joint near the articulation of fourth tarsal, third metatarsal bones; and along the plantarolateral aspect of the joint between the third tarsal and third metatarsal bones; the centrolateral aspect of the joint; in and around the intrasoosseous ligament; and the plane of the third tarsal and third metatarsal bones; and along the plantarolateral aspect of the joint near the articulation of fourth tarsal, third tarsal, third metatarsal, and fourth metatarsal bones. Because the injection site was at the plantarolateral aspect of the joint, it appears that the ethyl alcohol had the greatest effect in areas where the chemical was directly injected. The specific gravity of ethyl alcohol (0.789), compared with the reported value for normal joint fluid (1.014), may explain the localization of lighter fluid (ethyl alcohol) to the lateral aspect of the joint (uppermost during injection). After administration of ethyl alcohol, cartilage on the lateral aspect of the tarsometatarsal joint was exposed to higher initial concentrations, compared with the remainder of the joint. Effects of this initial high concentration of ethyl alcohol on the articular cartilage may explain the preponderance of fusion of the lateral aspect of the joint.

The importance of this finding is unknown at this time; naturally occurring fusion in horses is more advanced in the medial aspect of the joint. In theory, union of the bones at any location in the joint should alleviate the independent movement of the tarsal bones across the entire joint and the subsequent pain. The authors were unaware of any scientific information regarding the degree of bony fusion across the tarsometatarsal and distal intertarsal joints that is required to alleviate the pain associated with osteoarthritis.

Complete obliteration of the tarsometatarsal joint was not detected in any tarsus 12 months after treatment with ethyl alcohol, but lack of complete fusion should not preclude the treatment from achieving the goal of relieving pain. It has been suggested that local areas of arthrodesis may be sufficient to eliminate lameness.

Radiographic evidence of fusion in some reports does not appear to directly correlate with soundness. The authors believe that the focal fusion observed in the present study should provide stability similar to the use of intra-articular drilling techniques. Results indicate that ethyl alcohol is lethal to chondrocytes. Whether chondrocyte death and rapid disruption of the hyaline matrix are a result of ethyl alcohol’s nonselective protein denaturation and cell protoplasm precipitation and dehydration is yet to be examined.

The protocol used for administration of the ethyl alcohol met 1 objective of an ideal treatment—it was minimally invasive. Ethyl alcohol is a clear liquid with minimal viscosity, which allows easy intra-articular injection through standard-sized hypodermic needles commonly used for injection of the tarsometatarsal and distal intertarsal joints. Horses in this study were anesthetized for the intra-articular injections because they had minimal handling prior to the initiation of the study, but this treatment could be administered to a standing horse as with other intra-articular administrations. One factor that must be taken into consideration if administering ethyl alcohol intra-articularly in the distal intertarsal and tarsometatarsal joints is the potential for communication with more proximal joints; contrast arthrograms would be essential.

Exposure of the proximal 2 tarsal joints to ethyl alcohol would be disastrous in a manner similar to treatment with monoiodoacetate.

The present study focused on the effects of intra-articular ethyl alcohol in the tarsometatarsal joints, rather than the distal intertarsal joints, because the goal of the study was simply to assess the effect of ethyl alcohol in a low-motion, small tarsal joint with as few confounding variables as possible. We postulate that in clinical cases, intra-articular injection of ethyl alcohol in the distal intertarsal joint should yield similar results.
a. Rompun. Bayer Inc. Etobicoke, ON, Canada.
b. Vetalar. Bioniche Inc, Belleville, ON, Canada.
c. Butazone. Bioniche Inc, Belleville, ON, Canada.
d. Euthanyl. Biomedical-MTC, Lavalltrie, QC, Canada.
e. Dormosedan. Pfizer Canada Inc, Kirkland, QC, Canada.
f. Torbugesic. Wyeth Canada, Guelph, ON, Canada.
g. Enceprin-T. Invervet, Whiteby, ON, Canada.
h. Recombiket West Nile. Merial Canada Inc, Baie d’Urfé, QC, Canada.

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