Review Article

Diagnostic analgesia of the equine digit

J. Schumacher*, M. C. Schramme†, J. Schumacher‡ and F. J. DeGraves§

Sports Medicine, College of Veterinary Medicine, Auburn University, Alabama, USA; †Equine Clinic, National Veterinary School of Lyon, Marcy l’Etoile, France; ‡Department of Large Animal Clinical Sciences, College of Veterinary Medicine, University of Tennessee, Tennessee, USA; and §Ogden College of Science and Engineering, Western Kentucky University, Kentucky, USA.

*Corresponding author email: schumjo@auburn.edu

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Summary

Analgesia usually occurs within 5 min after administration of local anaesthetic solution into joints or around nerves in the distal portion of the limb. Gait should be assessed within 10 min after diagnostic regional analgesia of the distal portion of the limb because rapid diffusion of anaesthetic solution can result in anaesthesia of other nerve branches, thus confusing results of the examination. A palmar digital nerve block (PDNB) anaesthetises most of the foot, including the distal interphalangeal (DIP) joint (coffin joint), rather than just the palmar half of the foot, as was once commonly believed. To avoid partially anaesthetising the proximal interphalangeal joint (pastern joint), the palmar digital nerves should be anaesthetised near or distal to the proximal margin of the collateral cartilages. Clinicians should be aware that an abaxial sesamoid nerve block (ASNB) may ameliorate or abolish pain within the metacarpo/metatarso-phalangeal joint (fetlock joint). Mepivacaine administered into the DIP joint desensitises the DIP joint and probably the palmar digital nerves to also cause anaesthesia of the navicular bursa, the navicular bone, the toe region of the sole, the digital portion of the deep digital flexor tendon (DDFT) and the distal portions of the collateral ligaments of the DIP joint. When a large volume of mepivacaine HCl (e.g. 10 ml) is administered, the heel region of the sole may also be desensitised. Only a small percentage of horses with disease of the collateral ligament(s) of the DIP joint show a significant improvement in lameness after intra-articular analgesia of the DIP joint, and no horse is likely to improve after intrabursal analgesia of the navicular bursa. A PDNB, however, improves lameness substantially in most horses that are lame because of disease of the collateral ligament(s) of the DIP joint, and all affected horses are likely to become sound after an abaxial sesamoid nerve block. The degree of improvement in lameness associated with injury to one or both collateral ligaments of the DIP joint after PDNB is determined by the extent of the injury and the level at which the palmar digital nerves are anaesthetised. The further proximal the level of the injury within the collateral ligament, the less likely that lameness is ameliorated by analgesia of the DIP joint or a PDNB. Verschooten’s technique appears to be the most accurate technique for centesis of the navicular bursa. Even though analgesia of the DIP joint results in analgesia of the navicular bursa, analgesia of the navicular bursa does not result in analgesia of the DIP joint. Pain arising from the DIP joint can probably be excluded as a cause of lameness when lameness is attenuated by analgesia of the navicular bursa. Analgesia of the digital flexor tendon sheath (DFTS) is likely to desensitise only structures that are contained within or border on the sheath itself (i.e. the superficial and deep digital flexor tendons, the straight and oblique collateral sesamoidean ligaments, the annular ligaments of the fetlock and pastern, and the portion of the DDFT that lies within the foot). Because lameness caused by disease of the DDFT within the foot may fail to improve appreciably after analgesia of the palmar digital nerves, the DIP joint, or the navicular bursa, a portion of the DDFT within the foot and distal to the DFTS probably receives its sensory supply from more proximal deep branches of the medial and lateral palmar digital nerves that enter the DFTS. Performing intra-articular analgesia of the DFTS on horses with lameness that is unchanged after anaesthesia of the palmar digital nerves but resolves after an ASNB, may be useful in localising lameness to that portion of the DDFT that lies within the foot. Resolution of lameness after intraarticular analgesia of the DFTS justifies suspicion of a lesion within the digital portion of the DDFT or within structures contained within the DFTS. The belief that concurrent or sequential intra-articular administration of medication substantially increases the risk of joint infection or that inflammation caused by the local anaesthetic solution may dampen the therapeutic response to intra-articular medication appears to be unfounded.

Introduction

Until recently, there was little scientific basis for interpreting response to various techniques of diagnostic analgesia of the digit. As a result, some diseases, such as navicular disease, were often over-diagnosed, and others over-looked. Recently, some clinicians began to question long-held beliefs concerning analgesic techniques of the foot, especially that analgesia of the distal interphalangeal (DIP) joint (coffin joint) localised pain to that structure or that a palmar digital nerve block (PDNB) localised pain to the palmar half of the foot (Pleasant 1997; Dyson 1998; Trotter 1999; Bassage and Ross 2003). In recent years, many studies have examined the response to diagnostic analgesia of horses lame because of pain in a particular structure or region of the foot. Clinical observations, anatomical studies, magnetic resonance images of feet of horses with lameness caused by foot pain and results of clinical trials that created pain in certain structures of the foot have helped to clarify interpretation of the results of regional, intra-articular and intrabursal analgesia of the foot of horses. These studies have also highlighted the limitations of diagnostic analgesia of the horse’s digit. In this
paper, we present a summary of current knowledge of the use of analgesia to localise sites of pain within the digit of lame horses.

Assessment of lameness before application of local anaesthetic techniques

Before performing regional analgesia, the horse should be consistently and sufficiently lame so that any improvement in gait can be detected. Lunging or riding the horse may exacerbate a subtle lameness. The lameness of some horses improves or resolves during exercise, and so, for these horses, a false positive response to regional analgesia may result if the horse has not been sufficiently exercised before it is examined for lameness. If a horse is subtly lame, independent observation and grading of its gait before and after regional analgesia by 2 or more clinicians skilled at lameness examination may increase the accuracy of interpretation. Video-recordings of gait before and after diagnostic analgesia enable blinded assessment of the response to local anaesthetic techniques and remove bias from the subjective interpretation of results, especially when lameness is mild (Arkell et al. 2006). Similarly, the use of computerised methods to detect and quantify gait asymmetry before and after the use of diagnostic analgesia can also result in more objective interpretation of the effect of regional analgesia (Keegan 2007).

Preparation of skin for injection of local anaesthetic solution

Cleaning the site of injection with 70% isopropyl alcohol usually is sufficient for perineural administration of local anaesthetic solution. When the distal portion of the limb is particularly dirty, however, the injection site should be scrubbed with antiseptic soap. As long as local anaesthetic solution is deposited subcutaneously, complications from poor aseptic technique are unlikely. The clinician should be aware, however, of the potential for disastrous results when nonsterile technique is used, and a needle is misdirected into an adjacent synovial structure, such as the digital flexor tendon sheath (DFTS) or the proximal interphalangeal (PIP) joint (pacinian joint). The injection site of a synovial structure should be aseptically prepared, but one study showed that clipping of hair over the injection site is not necessary for aseptic arthrocentesis, as long the site is scrubbed for at least 7 min (Hague et al. 1997). In fact, another study showed that clipping or shaving hair before inserting a sharp hypodermic needle into a joint increases the risk of contaminating the joint with hair (Adams et al. 2010). If a stylierted needle is used for arthrocentesis, hair should be removed from the injection site or the stylet removed because hair is often caught between the stylet and the needle shaft. The same study also showed that allowing synovial fluid to drip from the needle before injecting medication decreased contamination of the joint with hair. Drawing the drug for intrasynovial deposition from an unused bottle may decrease the likelihood of introducing bacterial contaminants into the synovial structure.

Some clinicians consider the addition of an antimicrobial to the local anaesthetic solution to be contraindicated because of the risk of intrasynovial precipitation of the antimicrobial (Wright et al. 1995). Amikacin is a good choice of antimicrobial for clinicians who prefer to administer an antimicrobial along with local anaesthetic solution because 500 mg of amikacin administered into a normal joint provides a concentration above the reported MIC for most equine pathogenic bacteria for 72 h with minimal inflammatory effects (Taintor et al. 2006).

Choice of local anaesthetic agent

The first recorded use of local anaesthesia for diagnosis of lameness in the horse was in 1885 when a Pennsylvania veterinarian used cocaine for regional nerve blocks of the limbs (Steffey and Booth 1995). Cocaine was eventually replaced by procaine (Novocaine, developed in 1905) as the most commonly used local anaesthetic agent in veterinary practice. Procaine, however, has no topical effect and so is of no value when administered intra-articularly for lameness evaluation (Adams 1974). By the late 1940s, lidocaine was the most commonly used local anaesthetic agent for regional and intra-articular analgesia in the horse. Mepivacaine HCl was available for human use in the early part of the 1960s and approved for use in horses in the USA in 1977.

Another local anaesthetic agent that has been used for regional and intra-articular analgesia in the horse is 1% hexylcaine HCL (Cyclaine), which has a shorter duration of action and elicits a milder inflammatory reaction than does lidocaine (Riebold et al. 1982). Two percent prilocaine (Citanest) is also used for perineural anaesthesia and intra-articular analgesia because it causes very little tissue reaction (Dyson 1984). Two percent lidocaine HCl and 2% mepivacaine HCl are the local anaesthetic agents most commonly used to induce regional analgesia during lameness examination. Mepivacaine HCl is preferred for lameness examination by most clinicians because it has a more rapid onset of action and causes less tissue reaction than does lidocaine HCl (Specht et al. 1988). Although we have never observed lameness resulting from intra-articular administration of lidocaine in the elbow or shoulder joint of horses, we have observed temporary, severe lameness, presumably from inflammation, associated with its use in joints of the distal portion of the limb.

Experimentally, perineural administration of 2% or 3% ketamine HCl in isotonic saline solution or bicarbonate solution at the base of the proximal sesamoid bones resulted in 15–25 min of analgesia (Lopez-Sanromán et al. 2003a,b), and 0.02 mg/kg bw detomidine HCl mixed with isotonic saline solution ameliorated lameness when administered into the DIP joint of horses made lame from set-screw pressure on the sole (Sardari et al. 2006).

The choice of anaesthetic agent may depend on its duration of action. Mepivacaine provides resolution of lameness for about 55 min when administered into the middle carpal joint of horses lame from pain in that joint (Andreen et al. 1994). When mepivacaine is administered perineurally, its anaesthetic effect lasts 90–120 min (Wyn-Jones 1988) and, in some cases, up to 3 h, which makes this local anaesthetic agent valuable for examining a horse with lameness in multiple limbs or when multiple sites of pain in a limb are suspected. Lidocaine, which has an anaesthetic effect of only 30–45 min when administered perineurally (Wyn-Jones 1988), might be the preferred local anaesthetic agent when comparison of different techniques of diagnostic analgesia is likely to be used during the lameness examination.
Onset of analgesia

Onset of analgesia occurs rapidly after perineural or intra-articular administration of local anaesthetic solution. Andreen et al. (1994) observed resolution of lameness within 5 min after injecting mepivacaine into the middle carpal joint of horses lame because of pain associated with that joint. Intra-articular administration of local anaesthetic solution into joints of the distal portion of the limb also usually results in analgesia within 5 min (Fürst 2006). Onset of analgesia after perineural administration of local anaesthetic solution in the distal portion of the limb also occurs very quickly. The first re-evaluation of lameness can begin 5 min after administering regional analgesia in the distal portion of the limb (Wyn-Jones 1988; Fürst 2006). Wyn-Jones (1988) advised rapid assessment of gait after regional analgesia of the distal portion of the limb because rapid diffusion of anaesthetic solution could anaesthetise other nerve branches, thus confusing results of the examination. Nagy et al. (2009) found that radiopaque contrast medium deposited perineurally at the base of the proximal sesamoid bones travelled a significant distance proximally along the neurovascular bundle within 10 min after administration (Fig 1). They theorised that proximal diffusion of anaesthetic solution was also likely, which would explain the reason for decreased specificity over time of nerve blocks of the distal portion of the limb.

Some clinicians have observed a delay in the onset of analgesia for up to 10 min after performing perineural analgesia in the distal aspect of the limb (Nagy et al. 2009). Deposition of local anaesthetic solution outside the fascia (Fig 1) surrounding the neurovascular bundle has been offered as an explanation for this observation (Nagy et al. 2009). When the gait remains unchanged, some clinicians recommend waiting a minimum of 20 min before proceeding to the next block (Fürst 2006). It would be impossible for a clinician to know, however, if a delayed response to a nerve block of the distal portion of the limb was caused by injection outside the fascia surrounding the neurovascular bundle or by proximal diffusion of anaesthetic solution along the fascial plane with resulting analgesia of unintended structures. We believe that if the horse shows no response to a nerve block of the distal portion of the limb by 10 min after injection, the results of the block should be considered negative.

Most nerves below the carpus or tarsus are anaesthetised using a 25 gauge, 1.59 cm needle. To avoid broken or bent needles during perineural administration of local anaesthetic solution, the needle should always be inserted detached from the syringe. Luer-lock syringes should not be used because they are difficult to attach to the needle after the needle is inserted. The needle should be directed distally during insertion when anaesthetising nerves in the distal portion of the limb. Proximal migration of local anaesthetic solution probably occurs with most perineural injections in the distal portion of the limb (Nagy et al. 2009), and directing the needle proximally may accelerate this migration and confuse results of the examination.

Some clinicians prefer to test the dermatome desensitised by a nerve block before re-evaluating the horse’s gait. We prefer to check the accuracy of a nerve block by evaluating the gait after diagnostic analgesia. A positive response indicates an accurate nerve block. If the gait is unchanged after regional analgesia, the effectiveness of the nerve block should be determined by checking for skin sensation within the dermatome expected to be desensitised. Skin sensation is assessed by pressing the tip of a ballpoint pen, key or similar instrument over the skin covering the region intended to be desensitised. For a fractious horse, skin sensation is more safely checked with the limb held or checked from a distance using a blunt instrument, such as a ballpoint pen taped to a 1 m pole. A well-behaved, stoic horse may not react to stimulation of skin even though regional analgesia was ineffective. For such a horse, reaction to cutaneous stimulation of the skin may also provide evidence of the effectiveness of the block if the horse reacted to application of a hoof tester before application of regional analgesia.

When performing regional analgesia, especially in the distal portion of the limb, local anaesthetic solution can be administered inadvertently into a blood vessel, joint, tendon sheath or bursa. Administering the anaesthetic solution as the needle is withdrawn decreases the likelihood of depositing the solution in an unintended structure and results in deposition of the solution in more than one tissue plane, which increases the likelihood of the solution contacting the nerve.

Restraint of the horse for local analgesia

Regional analgesia of the distal portion of the limb of most horses can be accomplished using minimal restraint, but for fractious horses or for horses that have previously been subjected to regional analgesia, using a lip twitch or lip chain is prudent. Not all horses respond in the same way to different methods of restraint, but for most horses, application of a lip twitch provides adequate restraint. The twitch works best when applied immediately prior to placing the needle.

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Fig 1: Radiopaque contrast medium injected at the site of a lateral palmar digital nerve block at the level of the PIP joint 10 min before the distal portion of the limb was radiographed, has travelled proximally, as well as distally, along the neurovascular bundle (arrow). Proximal diffusion of anaesthetic solution along the neurovascular bundle may explain the reason for decreased specificity over time of nerve blocks of the distal portion of the limb. Deposition of local anaesthetic solution outside the fascia surrounding the neurovascular bundle (arrowhead) has been offered as an explanation for a delay in the onset of analgesia.
If application of a lip twitch or lip chain does not provide sufficient restraint, xylazine (0.2 mg/kg bw) or detomidine (10 μg/kg bw) can be administered intravenously to most horses without decreasing the degree of lameness (Dyson and Kidd 1993; Buchner et al. 1999). We have experienced that sedation of a fractious horse may actually make a subtle lameness more obvious. Xylazine may be more useful for restraint than detomidine because of its shorter duration of action. A low dose, such as 5 mg, of intravenously administered acepromazine can also be useful for restraining a fractious horse during diagnostic analgesia without interfering with interpretation of the lameness examination (Ross 2003; Fürst 2006). The degree to which sedation or tranquilisation may interfere with assessment of gait, however, may depend on the severity of lameness and the skill of the clinician performing the examination. Because of the uncertainty of the effect of sedation or tranquilisation on gait, a sedative or tranquiliser is best avoided, if possible. When the horse must be sedated to administer local anaesthetic solution, antagonising the sedative effects of an α2-agonist, such as xylazine, with yohimbine (0.12 ± 0.02 mg/kg bw) or tolazoline (7.5 ± 1.1 mg/kg bw) (Kollas-Baker et al. 1993) may make interpretation of diagnostic analgesia easier.

Regional analgesia of the distal portion of the limb usually requires multiple injections, and these injections are most safely administered with the limb held off the ground. When a nerve block is performed with the horse’s limb on the ground, the contralateral limb can be lifted off the ground to enhance the safety of the procedure for the clinician. Some horses with a limb lifted off the ground, however, have a tendency to drop to their knees when the needle is inserted.

When anaesthetising the foot of a forelimb, most clinicians prefer to hold the limb while facing in the opposite direction to the horse, whereas some prefer to face in the same direction as the horse. When facing in the same direction as the horse, the foot can be held between the clinician’s knees to free both hands for the procedure, but the clinician is at risk of injury if the horse swings its limb caudally. When the clinician faces in the opposite direction, the procedure is performed using one hand because the other hand must hold the limb. Nerve blocks performed below the fetlock of the pelvic limb are most safely performed with the pelvic limb lifted, stretched caudally and the fetlock held on the thigh of the clinician performing the block.

**Volumes of local anaesthetic solution administered for analgesia of the foot**

To administer a PDNB, 1.5 ml of mepivacaine deposited over each palmar digital nerve are sufficient to consistently anaesthetise those nerves. Administering larger volumes of local anaesthetic solution increases the likelihood of anaesthetising branches of the palmar digital nerve that supply the PIP joint (Schumacher et al. 2004). To administer an abaxial sesamoid nerve block (ASNB), 2.5 ml of mepivacaine deposited over each palmar digital nerve are sufficient to consistently anaesthetise those nerves and the dorsal branches of the digital nerve that lie in close proximity. Administering larger volumes of local anaesthetic solution increases the likelihood of anaesthetising branches of the palmar digital nerve that supply the metacarpal/metatarsal phalangeal (MC/MT-P; fetlock) joint.

Five to 6 ml of mepivacaine are commonly administered into the DIP joint to anaesthetise that joint and the navicular apparatus. The toe of the sole is also desensitised, and administering a larger volume of local anaesthetic solution increases the likelihood of anaesthetising branches of the palmar digital nerve that supply the heel region of the sole (Schumacher et al. 2001a).

**Anaesthesia of the palmar digital nerves**

Clinicians have long believed that a positive response to anaesthesia of the palmar digital nerves of lame horses localises pain to the palmar third or half of the foot, including the palmar aspect of the DIP joint (Adams 1974; Stashak 1987). Easter et al. (2000) found, however, that anaesthesia of the palmar digital nerves proximal to the bulbs of the heel alleviates lameness caused by endotoxin-induced pain in the DIP joint, indicating that the palmar digital nerves innervate the entire DIP joint. The study by Easter et al. (2000) corroborated an anatomical study that demonstrated that the dorsal branches of the palmar digital nerves do not innervate the DIP joint (Sack 1975). One of the current authors (M.C.S.) has observed that anaesthesia of the palmar digital nerves may not resolve lameness in horses with osteoarthritis of the DIP joint if subchondral bone of the middle phalanx is diseased; this is most likely to be because subchondral bone is innervated by nerve branches that enter the bone through its nutrient foramen (Dyson 1986; Niv et al. 2003) and lie proximal to the site of the nerve block (Fig 2).

Some clinicians describe the proper site for anaesthesia of the palmar digital nerves to be anywhere from the proximal margin of the collateral cartilage to the mid pastern region (Wright et al. 1995), but others believe that the nerves should be anaesthetised near or distal to the proximal margin of the collateral cartilage (Beeman 1988; Wyn-Jones 1988; Stashak 2002; Bassage and Ross 2003) (Fig 3). One theoretical advantage of anaesthetising the palmar digital nerves as far...
nerve block. Lameness should be re-evaluated within 10 min of administering the solution as far distally in the pastern as possible when performing a PDNB is that more proximal deposition of local anaesthetic solution increases the likelihood of causing partial analgesia of the PIP joint, local anaesthetic solution should be deposited at or distal to the margin of the collateral cartilage (needle a).

A more important reason for depositing local anaesthetic solution as far distally in the pastern as possible when performing a PDNB is that more proximal deposition of local anaesthetic solution increases the likelihood of causing analgesia of the PIP joint (Schumacher et al. 2004). When a 25 gauge, 16 mm needle is inserted over the palmar digital nerve 1 cm proximal to the proximal edge of the cartilage of the foot and directed distally, the needle tip is placed at the level of the proximal edge of the collateral cartilage for deposition of local anaesthetic solution. Insertion of a needle at this site causes local anaesthetic solution to be deposited at or slightly distal to the level of the palmar border of the PIP joint, because the height of the collateral cartilage in relation to the level of the palmar border of the PIP joint is probably similar for most horses (Schumacher et al. 2004). As another precaution to avoid inadvertent analgesia of the PIP joint, we also recommend that no more than 1.5 ml of local anaesthetic solution be deposited over each palmar digital nerve and that lameness be re-evaluated within 10 min of administering the nerve block.

Ring block
A ring block, performed at the recommended level of a PDNB (i.e. at or below the upper margin of the collateral cartilage), is unlikely to result in a positive response after a negative response to a PDNB, because the dorsal branches of the palmar digital nerves contribute little to sensation within the foot (Easter et al. 2000). The PDNB will already have anaesthetised the entire foot, with the exception of the dorsal portion of the coronary band and the dorsal laminae of the foot. The use of a pastern ring block performed at mid pastern level, however, should be considered as a better alternative to the ASNB, because the ASNB may inadvertently partially or entirely desensitise the MC/MT-P joint in addition to the entire foot and pastern, which can lead to an erroneous localisation of pain in the foot or pastern region in horses with fetlock pain. A positive response to a ring block performed at mid pastern level, after a negative response to a PDNB, localises lameness to the pastern region or the dorsal region of the toe.

ASNB
Bassage and Ross (2003) distinguish between anaesthesia of the palmar or plantar digital nerves performed at the base of the proximal sesamoid bones (i.e. a basisesamoid block) and anaesthesia performed alongside the proximal sesamoid bones (i.e. an ASNB). They believe that the basisesamoid block is unlikely to anaesthetise the dorsal branches of the palmar digital nerve, which is contrary to our experiences. Whether or not these dorsal branches are anaesthetised probably has little bearing on the results of a lameness examination because the dorsal branches of the palmar digital nerves contribute little to sensation within the foot (Easter et al. 2000). Anaesthesia of the digital nerves and their dorsal branches, at either level, alongside or at the base of the proximal sesamoid bones, desensitises the foot, the PIP joint, the middle phalanx and associated soft tissues, and the distal and palmar aspects of the proximal phalanx. Clinicians should be aware that an ASNB or basisesamoid nerve block may ameliorate or abolish pain within the MC/MT-P joint (Wyn-Jones 1988; Barr 1997; Bassage and Ross 2003; Dyson and Murray 2006), especially if excessive time elapses before assessment to allow proximal migration of local anaesthetic solution along the neurovascular bundle.

Performing the nerve block at the base of the proximal sesamoid bones (i.e. a basisesamoid block) decreases the likelihood of partially desensitising the MC/MT-P joint (Wyn-Jones 1988). Using a small volume of local anaesthetic solution (i.e. ≤2.5 ml) and directing the needle distally, rather than proximally, may also decrease the likelihood of partially anesthetising the MC/MT-P joint. Because local anaesthetic solution is likely to diffuse proximally after perineural injection (Nagy et al. 2009), we recommend that the horse’s gait be evaluated within 10 min of an ASNB.

Analgesia of the DIP joint
Several approaches to the DIP joint have been described and include a dorsal perpendicualr approach (i.e. perpendicular to the bearing surface) (Moyer et al. 2007); a palmar approach (McIlwraith and Goodman 1989); a dorsal lateral approach (Fig 4a) a dorsal parallel approach (Fig 4b) (Moyer et al. 2007) and a dorsal inclined approach (Fig 4c) (Gandini 2007), and a lateral approach (Fig 4d) (Vazquez de Mercado and Stover 1998; Vazquez de Mercado et al. 1998). Administering local anaesthetic solution into the DIP joint is most easily accomplished using a dorsal parallel or inclined approach, where a needle is placed into the dorsal pouch of the DIP joint on or near midline, just proximal to the coronary band, rather
Mepivacaine administered into the DIP joint desensitises the DIP joint (Stashak 2002), the navicular bursa (Pleasant et al. 1997), the navicular bone (Scheibitz 1964; Dyson and Kidd 1993; Turner 1996), the toe region of the sole (Schumacher et al. 2000, 2001a) and the digital portion of the deep digital flexor tendon (DDFT) of most horses (Dyson et al. 2003). When a large volume of mepivacaine HCl (e.g. 10 ml) is administered, the heel region of the sole may also be desensitised (Schumacher et al. 2001a).

Possible explanations for analgesia of the navicular apparatus (i.e. the navicular bone and its associated ligaments) after local anaesthetic solution is administered into the DIP joint include the desensitisation of subsynovial nerves that supply sensory fibres to the navicular bone and its collateral sesamoidean ligaments (Bowker et al. 1993) and the desensitisation of the palmar digital nerves where they lie in close proximity to the palmar pouch of the DIP joint (Calislar and St. Clair 1969; Pleasant et al. 1997) (Fig 5). Occasionally, the palmar aspect of the coronary band is desensitised after anaesthesia of the DIP joint (Schumacher et al. 2001a), supporting the theory that analgesia of the DIP joint causes desensitisation of the palmar digital nerves. Additionally, Gough et al. (2002) found evidence for diffusion of local anaesthetic solution from the DIP joint into the navicular bursa in cadaver limbs, and Keegan et al. (1996) demonstrated diffusion of mepivacaine from the DIP joint into the navicular bone in vivo. In both diffusion studies, the concentration of mepivacaine found in the navicular bursa or navicular bone was high enough to desensitise those structures.

A negative response to intra-articular analgesia of the DIP joint may not eliminate the navicular bone and its related structures as the source of lameness. In a study of 102 horses with chronic foot pain, Dyson (1995) found that 21% of horses failed to respond to intra-articular analgesia of the DIP joint but improved significantly after intrabursal analgesia of the navicular bursa. A later study showed that some lesions of the DDFT at the level of the tendon’s insertion to the distal phalanx may be more effectively desensitised by administration of local anaesthetic solution into the navicular bursa than by analgesia of the DIP joint (Schramme et al. 2002). Some of the lame horses in Dyson’s study (1995) that responded to analgesia of the navicular bursa, but were unresponsive to analgesia of the DIP joint, may have had lesions of the insertion of the DDFT rather than disease of the navicular bone and its related structures.
though the presence of solar pain can be eliminated with hoof testers.

Clinical impressions suggest that the degree of improvement in lameness associated with collateral ligament injury after PDNB is determined by the extent of the injury and the level at which the palmar digital nerve is anaesthetised. The further proximal the level of the injury within the collateral ligament, the less likely that lameness is affected by analgesia of the DIP joint or anaesthesia of the palmar digital nerve. This observation suggests that the branches innervating the proximal aspect and origin of the collateral ligaments may arise from the palmar digital nerves, proximal to the site where the palmar digital nerves abut the palmar pouch of the DIP joint or from the dorsal branches of the palmar digital nerve. A pastern ring block or ASNB may be required to abolish lameness when osseous remodelling is present at the origin of the collateral ligament at the level of the middle phalanx.

Diagnostic analgesia of the collateral ligaments of the DIP joint

Lameness caused by disease of the collateral ligaments of the DIP joint often fails to improve significantly after analgesia of the DIP joint itself (Dyson and Murray 2004). Only 24% of 30 horses with MRI evidence of collateral ligament disease showed a significant improvement in lameness after intra-articular analgesia of the DIP joint, and none of the horses improved after intrabursal analgesia of the navicular bursa. A PDNB, however, improved lameness significantly in 72% of these horses, and all became sound after an ASNB. Consequently, when lameness is abolished by a PDNB but not by analgesia of the DIP joint or navicular bursa, and no radiographic abnormalities of the foot can be detected, collateral desmitis of the DIP joint must be considered as a possible cause of lameness, as long as the presence of solar pain can be eliminated with hoof testers.

Intra-articular and perineural analgesia of the PIP joint

A positive response to intra-articular analgesia of the PIP joint localises pain causing lameness to that joint. Not all horses that are lame because of PIP joint pain, however, respond positively to intra-articular analgesia of the PIP joint. Intra-articular analgesia may relieve pain caused by disease of periosteal and capsular soft tissue, but when joint disease involves subchondral bone, lameness may not resolve (Dyson 1986). Because subchondral bone is innervated by nerves that enter the bone marrow via the nutrient foramen, anaesthesia of nerves proximal to the branches that enter the nutrient foramen may be necessary, in some cases, to resolve joint pain and lameness. Because the PIP joint is innervated by branches of the palmar digital nerves and their dorsal branches (Sack 1975), either an ASNB or basisesamoid nerve block resolves lameness caused by pain in the PIP joint. Perineural anaesthesia of the palmar digital nerves and their dorsal branches at this location should also anaesthetise these nerves proximal to the origin of the branches that enter the nutrient foramen of the proximal phalanx and resolve lameness caused by subchondral bone pain.

Several techniques for analgesia of the PIP joint have been described. The authors prefer a modification of the palmar approach described by Miller et al. (1996) because using this approach usually allows recovery of joint fluid joint fluid to indicate proper needle placement and is less resented by the horse than a dorsal approach. The procedure is performed with the limb held. A 20 gauge, 25 mm needle is inserted perpendicular to the long axis of the pastern, close to the palmar border of the first phalanx, just proximal to the easily palpable transverse bony prominence on the proximopalmar aspect of the middle phalanx. The needle is inserted through the skin with the joints of the distal portion of the limb extended. These joints are flexed, and the needle is advanced into the palmar pouch of the PIP joint (Fig 7). This method of centesis is easily performed because the palmar pouch of this joint is extensive (Fig 8).

Intra-articular analgesia of the MC/MT-P joint

Although a positive response to intra-articular analgesia of the MC/MT-P joint localises disease to that joint in most horses, not all lameness associated with an injury of the MC/MT-P joint resolves with intra-articular analgesia. Whereas lameness caused by intra-articular fragmentation, synovitis, capsulitis and osteoarthritis improves or resolves after intra-articular analgesia, lameness caused by injury of the subchondral bone or periarticular ligaments improves only after a low 4-point nerve block. As an exception to this rule, lameness caused by desmitis of the proximal portion of the straight or an oblique distal sesamoidean ligament is frequently abolished by intra-articular analgesia of the MC/MT-P joint (Sampson et al. 2007).

Several techniques are described for intra-articular analgesia of the MC/MT-P joint. The authors prefer the technique described by Misheff and Stover (1991), during which the limb is positioned in partial flexion by holding the foot with one hand, while the needle is introduced through...
The spinal needle is inserted between the bulbs of the heel just proximal to the coronary band, and the needle is advanced along a sagittal plane aiming for a point 1 cm below the coronary band, midway between the dorsal and palmar limits of the coronary band (Fig 10). The spinal needle is advanced until the tip of the needle contacts bone. At this time, a digital lateromedial radiograph can be taken to check the position of the needle prior to injection 3-4 ml of mepivacaine. Injection of the bursa may be facilitated by flexing the foot. Another method of determining success of the procedure is to examine the foot radiographically immediately after injecting the bursa, provided that 0.5-1.0 ml of radiopaque contrast medium was added to the local anaesthetic solution (Fig 11). Radiographic identification of contrast medium within the bursa is evidence of a successful bursal injection.

Successful centesis of the bursa can also be determined ultrasonographically (Spiet et al. 2004). For an ultrasonographic view of the navicular bone, the frog is trimmed to pliable tissue, and then soaked in warm water for 30-120 min; the time of soaking depends on the moisture content of the frog (Grewal 2007). The needle is advanced into the navicular bursa, using Verschooten’s method of centesis (Verschooten et al. 1991), and the position of the needle tip is determined using a 7.5 MHz linear probe placed on the frog in a sagittal orientation (Spiet et al. 2004). The needle is properly placed when the tip of the needle contacts the flexor surface of the navicular bone (Fig 12).

In the absence of radiographic equipment, successful centesis of the bursa might be assumed if the first 2 ml of local anaesthetic solution are easily administered and then, as pressure within the bursa increases as an additional 1-2 ml are administered, administration becomes more difficult, resulting in refilling of the syringe barrel with local anaesthetic solution when pressure on the plunger is released. When the tip of the needle is inserted too far proximally, it passes proximal to the navicular bone to enter the palmar pouch of the DIP joint, and when this occurs, a much larger volume of fluid (e.g. >7 ml) can be administered before pressure is encountered. Synovial fluid can usually be aspirated from the palmar pouch of the DIP joint but not from the navicular bursa.

A positive response to administration of local anaesthetic solution into the navicular bursa indicates disease of the navicular bursa, the navicular bone and/or its supporting ligaments (Dyson and Kidd 1993), solar toe pain (Schumacher et al. 2001b), or disease of the distal portion of the DDFT (Dyson 1998; Schramme et al. 2002). Even though analgesia of the DIP joint results in analgesia of the navicular bursa (Schebitz 1964; Pleasant et al. 1997), analgesia of the navicular bursa does not result in analgesia of the DIP joint (Dyson 1991, 1995, 1998; Dyson and Kidd 1993; Schumacher et al. 2003). Analgesia of the navicular bursa may help to differentiate pain associated with disease of the DIP joint from pain associated with disease of the navicular bone and associated structures. Pain arising from the DIP joint can likely be excluded as a cause of lameness when lameness is attenuated within 10 min by analgesia of the navicular bursa (Schumacher et al. 2003).

One possible explanation for the observation that analgesia of the DIP joint causes analgesia of the navicular bursa but analgesia of the navicular bursa does not cause analgesia of the DIP joint is that the site of direct contact between the palmar pouch of the DIP joint and the palmar

The collar lateral sesamoidean ligament into the space between the articular surface of the lateral sesamoid bone and the palmar aspect of the lateral metacarpal condyle (Fig 9). A volume of 10 ml mepivacaine is administered, and the lameness is assessed after 10 min.

Analgesia of the navicular bursa

A study comparing various techniques for inserting a needle into the navicular bursa showed that a method described by Verschooten et al. (1991) was the most accurate (Schramme et al. 2000). The foot can be held or placed in a Hickman block using this method. A 20 gauge, 8.9 cm, disposable, 20 gauge, 8.9 cm, disposable, Verschooten into the navicular bursa showed that a method described by Schumacher and Moll 2006).
digital nerves is located proximal to the origin of the deep branches that innervate the DIP joint and the navicular bursa, whereas the site of direct contact between the navicular bursa and the palmar digital nerves is located distal to these branches (Fig 13). Another possible explanation is that local anaesthetic solution may diffuse more slowly from the navicular bursa to the DIP joint than from the DIP joint to the navicular bursa (Wintzer et al. 1976; Bowker et al. 1993, 1995; Gough et al. 2002).

Several investigators (Wintzer et al. 1976; Bowker et al. 1993, 1995; Gough et al. 2002) found a significant difference between the extent of diffusion of various drugs from the DIP joint to the navicular bursa and the extent of diffusion of these drugs from the bursa to the DIP joint. In one study, 4 times more of a mixture of luxol-fast blue dye and mepivacaine diffused from the DIP joint into the navicular bursa (65%) than vice versa (12.5%) (Bowker et al. 1993). In a cadaver study, significantly more mepivacaine was found in the navicular bursa after injection of the DIP joint with mepivacaine than the converse (Gough et al. 2002).

In addition to experimental findings concerning the effect of analgesia of the navicular bursa, clinical observations indicate that a positive response to intra-articular analgesia of the DIP joint and a negative response to intrabursal analgesia of the navicular bursa indicate pain.

Fig 9: To perform arthrocentesis of the MC/MT-P joint, the limb is positioned in partial flexion by holding the foot with one hand, while the needle is introduced through the collateral sesamoidean ligament into the space between the articular surface of the lateral sesamoid bone and the palmar aspect of the lateral metacarpal condyle. (From Schumacher and Moll 2006)

Fig 10: To perform centesis of the navicular bursa, the foot can be held (a) or placed in a Hickman block (b). A 20 gauge, 8.9 cm, disposable, spinal needle is inserted between the bulbs of the heel just proximal to the coronary band, and the needle is advanced along a sagittal plane aiming for a point 1 cm distal to the coronary band, midway between the dorsal and palmar limits of the coronary band (c). Injection of the bursa may be facilitated by flexing the foot (d).

Fig 11: To determine if centesis of the navicular bursa was successful, the foot can be examined radiographically immediately after injecting the bursa with 0.5–1.0 ml of contrast medium added to the local anaesthetic solution. Radiographic identification of contrast medium within the bursa (arrow) is evidence of a successful bursal injection.
within the DIP joint as the cause of lameness (Turner 1996; Dyson 1998). This clinical observation is valid if solar pain can be eliminated with hoof testers as a cause of lameness (Schumacher et al. 2000, 2001a).

**The effect of time on interpretation of analgesia of the DIP joint or navicular bursa**

Some clinicians have assumed that improvement in lameness observed within 10 min after injection of the DIP joint with local anesthetic solution indicates that lameness is caused by pain in the DIP joint alone and that improvement observed more than 10 min after injection is caused by diffusion of local anesthetic solution into the navicular bursa or around the nerves providing sensory innervation to the navicular bone and its associated structures (Dyson 1991; Gough 1998). This assumption appears to be invalid because a positive response to intra-articular analgesia of the DIP joint has been observed to occur within 5–8 min of injection in a majority of horses with navicular disease or experimentally-induced navicular bursal pain (Pleasant et al. 1997; Dyson 1998).

Results of several trials indicate that the effect of intra-articular analgesia of the DIP joint or of intrabursal analgesia of the navicular bursa on lameness should be assessed soon after injection (i.e. within 5–10 min) because after this time, the structures that become desensitized by diffusion of the anesthetic solution become uncertain (Schumacher et al. 2001a,b, 2003).

**Analgesia of the DFTS**

Synoviocentesis of the DFTS can be performed by placing a 20–22 gauge needle into one of the sheath’s several pouches (Fig 14). Access to these pouches is not difficult when the sheath is distended with synovial fluid but is often difficult when it is not. An approach through the palmar/plantar annular ligament of the fetlock was found to be reliable for consistent synoviocentesis of the DFTS (Hassel et al. 2000). Using this approach, the MC/MT-P joint is flexed to a dorsal angle of 225°, the needle is placed through the skin at the level of the midbody of the lateral proximal sesamoid bone, and then through the palmar annular ligament, 3 mm axial to the palpable palmar border of the lateral proximal sesamoid bone, immediately palmar to the palmar digital neurovascular
bundle (Fig 15). The needle is inserted in a transverse plane and advanced at an angle of 45° to the sagittal plane, aiming toward the central intersesamoidean region, to a depth of 1.5–2.0 cm. This technique results in reduced time and fewer attempts required for successful entry into the sheath than the proximal lateral approach. The synovium in this location is less villous, cellular and mobile than in the proximal pouch, and, therefore, synoviocentesis is less likely to result in synovial haemorrhage. Adequate desensitisation of the DFTS is provided by 10 ml of local anaesthetic solution.

A recent study demonstrated that pain induced in the toe and heel regions of the sole, pain associated with synovitis of the DIP joint, and pain associated with synovitis of the navicular bursa were not significantly attenuated by intrathecal analgesia of the DFTS (Harper et al. 2007). It is logical, therefore, to assume that analgesia of the DFTS desensitises only structures that are contained within or border on the sheath itself (i.e. the superficial and deep digital flexor tendons, the straight and oblique distal sesamoidean ligaments, the annular ligaments of the fetlock and pastern, and the portion of the DDFT that lies within the foot).

**Diagnostic analgesia of the digital portion of the DDFT**

An ASNB abolished or improved lameness localised to the foot in all of 46 horses found to have a significant abnormality in the digital portion of the DDFT using MRI (Dyson et al. 2003). A PDNB, analgesia of the DIP joint, or analgesia of the navicular bursa, however, each ameliorated lameness of only about two-thirds of these horses. Because lameness caused by disease of the DDFT within the foot may fail to improve significantly after analgesia of the palmar digital nerves, the DIP joint, or the navicular bursa, we believe that a portion of the DDFT within the foot and distal to the DFTS receives its sensory supply from more proximal deep branches of the medial and lateral palmar digital nerves that enter the DFTS. Improvement of lameness in horses with similar lesions of the DDFT after intrathecal analgesia of the DFTS has been described (Schneider 2002).

Performing intrathecal analgesia of the DFTS on horses with lameness that is unchanged after anaesthesia of the palmar digital nerves but resolves after an ASNB, may be useful. Resolution of lameness after intrathecal analgesia of the DFTS justifies suspicion of a lesion within the digital portion of the DDFT or within structures contained within the DFTS.
Timing of intra-articular analgesia and intra-articular treatments

Although we can find no references for the recommendation that intra-articular administration of medication, such as corticosteroids or hyaluronic acid, be delayed for several days after intra-articular administration of local anaesthetic solution, such a delay seems to be a common practice of many veterinarians. The reason for this seems to be the belief that concurrent or sequential intra-articular administration of medication substantially increases the risk of joint infection or that inflammation caused by the local anaesthetic solution may dampen the therapeutic response to intra-articular medication (Caron and Genovese 2003).

Two recent studies investigated the effect of concurrent or sequential intra-articular administration of local anaesthetic solution and medication in equine joints (Zubrod et al. 2006; Kay et al. 2008). Results of one of those studies indicated that same-day intra-articular administration of local anaesthetic solution and hyaluronan and/or cortisone does not pose a substantial risk of joint sepsis, provided that adherence to aseptic technique is strict (Zubrod et al. 2006). A study that examined the effect of concurrent intra-articular administration of mepivacaine and triamcinolone acetonide found that mepivacaine had no effect on the potency or duration of action of triamcinolone (Kay et al. 2008).

Anaesthesia of the hindfoot compared to the forefoot

Innervation of the distal portion of the pelvic limb differs slightly from that of the thoracic limb because the medial and lateral dorsal metatarsal nerves, which are branches of the deep peroneal nerve, provide additional innervation to the digit and third metatarsal bone. In addition, the medial plantar metatarsal nerve may also continue distally into the coronary dermis. Because of this additional nerve supply to the distal portion of the pelvic limb, some clinicians recommend that the dorsal metatarsal nerves, in addition to the plantar metatarsal nerves, be anaesthetised when performing either a PDNB or an ASNB, by administering local anaesthetic solution subcutaneously medial and lateral to the long digital extensor tendon (Stashak 2002; Furst 2006). Other clinicians, however, believe that supplementing a PDNB or ASNB with anaesthesia of the dorsal and plantar metatarsal nerves is unnecessary (Wyn-Jones 1988; Wright et al. 1995; Carter and Hogan 1996; Barr 1997; Bassage and Ross 2003). The dorsal metatarsal nerves should be anaesthetised with a subcutaneous ring block or low 6-point nerve block when performing regional analgesia to localise lameness to the fetlock region because these nerves supply innervation to the dorsal portion of the metatarsophalangeal joint (Wyn-Jones 1988; Wright et al. 1995; Bassage and Ross 2003). Carter and Hogan (1996) claim, however, that most lamenesses involving the distal portion of the pelvic limb can be evaluated adequately without blocking the dorsal metatarsal nerves.

False positive and false negative results of diagnostic analgesia of the foot

Clinicians should be aware that techniques of diagnostic analgesia of the horse’s foot might provide misleading information concerning the site of pain causing lameness. Possible causes of false positive results have been discussed previously in this article but are summarised below:

• Failure to appreciate that a horse has ‘warmed out’ of lameness. The clinician should be convinced that lameness will not diminish with further exercise before proceeding with diagnostic analgesia.

• Failure to re-evaluate lameness within an appropriate time, thus allowing proximal diffusion of anaesthetic solution (Nagy et al. 2009).

• Clinician bias due to the expectation that the block will ameliorate lameness, especially if the lameness is subtle (Arkell et al. 2006).

Possible causes of false negative results are:

• Local anaesthetic solution could inadvertently and unknowingly be injected into a blood vessel (Schumacher et al. 2007).

• Misdirection of a needle causing deposition of local anaesthetic solution into an underlying synovial structure, rather than perineurally.

• Misdirection of a needle causing deposition of local anaesthetic solution outside the fascia surrounding the neurovascular bundle (Nagy et al. 2009).

• Failure of intra-articular anaesthesia to alleviate subchondral bone pain or pain associated with the joint capsule or collateral ligaments (Dyson 1986).

• Clinician bias due to the expectation that the block will not ameliorate lameness, especially if the lameness is subtle (Arkell et al. 2006).

In spite of the specific guidelines laid out in this paper, results of intrasynovial or regional analgesia of the foot may need to be interpreted with at least some degree of scepticism.

Authors’ declaration of interests

No conflicts of interest have been declared.

References


