

Investigating penetrating injuries of the equine hoof



Hoof injuries can severely impair equine mobility and can lead to long term implications. Here, Henry O'Neil and Bryan O'Meara assess the best ways to treat penetrating injuries of the equine hoof

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Injuries to the hoof require particular attention due to the unavoidable environmental contamination of the penetration site and the potential for involvement of some vital anatomical structures. Clinical signs for both superficial and deep puncture wounds frequently overlap and distinguishing between both types can be difficult on physical examination alone.



Figure 1: Although all penetrations to the sole should be carefully examined, those within the blue box require particular attention.

Wounds to any part of the sole within the limits of the white line have the potential to involve sensitive structures, however those penetrating the middle third of the sole (Figure 1) may contact important tendinous, synovial or bony structures (Figure 2). The outcome depends on

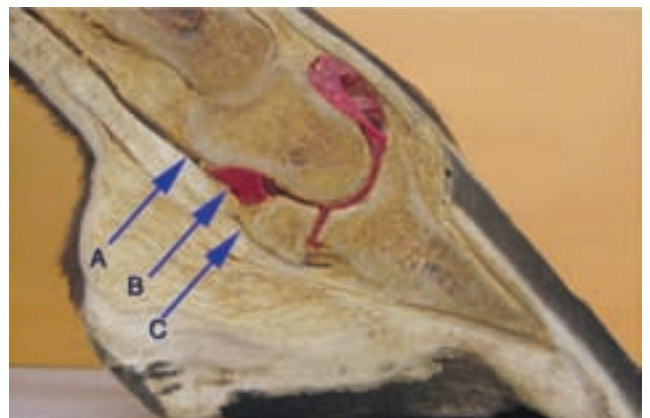


Figure 2: Sagittal section of the equine hoof. The palmar/plantar pouches (B) of the coffin joint are in close contact with the navicular bursa (C) and, more proximally, the digital flexor tendon sheath (A). It is important to keep this intimate relationship of the three structures in mind when a penetrating injury involves the palmar/plantar area of the frog, the central sulci or the cartilages of the third phalanx.

number of variables including the structures affected, the severity of the lesion and the delay in onset of treatment. The first aid administered to a patient at the initial visit can have a serious impact not only on the prognosis of the case but also has financial implications for the owner.

IF THE PENETRATING OBJECT IS STILL IN PLACE



Figure 3: A nail penetrating into the sole of the hoof. The nail has penetrated so deeply with the initial step that it is no longer weight bearing with the ground.

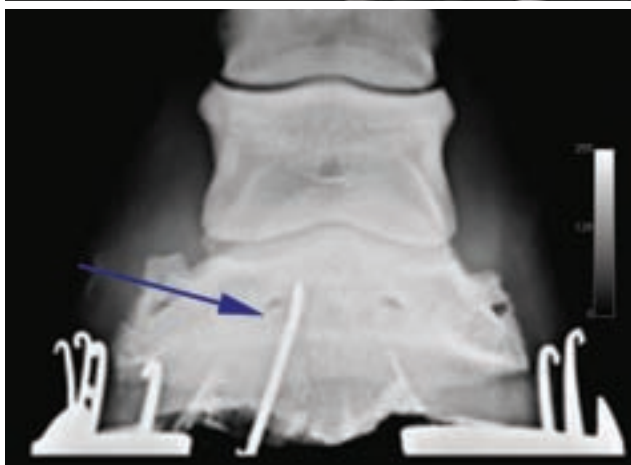


Figure 4A and B: Latero-medial (left) and dorso-palmar (right) radiographs respectively of a horse with a nail penetrating right through to the navicular bone (arrowed). With a penetration such as this, involvement of the deep flexor tendon, the navicular bursa and navicular bone is almost certain and will require early and aggressive surgical treatment.

Most horse owners have the tendency to remove penetrating objects upon discovery. However, it is most likely that the object has passed as deep as it will go after the horse has taken one step – i.e. just below the level of the horseshoe or flat with the sole in an unshod patient (**Figure 3**). The ability to radiograph the foot with the offending object still present provides the practitioner with the best visualisation of the depth and direction of the puncture, identifying any vital structures that may have been penetrated en route. A minimum of two views taken at right angles (e.g. a latero-medial and dorso-palmar radiographic view) to the foot is required to determine the accurate position of the foreign body (**Figure 4A and B**). If a long, free end of the object still remains outside the hoof capsule, this may be trimmed back so that only a small amount remains, and then a rigid support can be applied around it in to provide elevated support until such time that a radiograph can be taken.

Tetanus prophylaxis

The tetanus vaccination status should always be checked – if the owner is in doubt then prophylaxis with tetanus antitoxin followed up by vaccination is always advisable.

SUPERFICIAL SOLAR PENETRATIONS

Uncomplicated penetrations of the sole are one of the most common causes for a non-weight bearing lameness in the horse (**Figure 5**). In some instances where the offending object has been removed and the site of penetration is not initially apparent, a careful clinical examination will be necessary to determine the source of lameness. An increase in intensity of the digital pulse is often apparent, however the presence of an increased intensity is not exclusive to a foot penetration. Direct palpation of the hoof may detect heat beneath the wall. Application of hoof testers in a methodical fashion may localise the penetration site. For longer standing solar punctures, purulent material will dissect along the tissue planes of least resistance, either along the solar surface towards the heel bulbs or along the dorsal hoof wall, and burst out

along the coronary band. Patients often have a history of an intermittent lameness of variable severity. Purulent material may have been removed from suspicious tracts over the previous days or weeks but failed to resolve the lameness.

Treatment

Light paring of the sole and frog with a hoof knife is beneficial and can often lead to the discovery of an entry



Figure 5: The foot should always be comprehensively examined in the horse displaying a non-weight bearing lameness.

tract. In cases where an abscess is suspected but a tract is not readily apparent, the application of a wet poultice daily or hot tubbing the



Figure 6: Chronically draining tracts often require much more aggressive surgical debridement for resolution as shown.

foot in an Epsom salt solution several times a day can help soften the horn and allow for an easier follow up examination 24 hours later. For uncomplicated abscesses, the release of purulent material and the establishment of drainage are curative. Antimicrobial medication is generally not warranted unless involvement of the deeper sensitive structures is involved or blood is encountered during the investigation. The use of analgesia is not recommended by many clinicians, as it is believed that a subsequent increase in the severity of lameness or continued lameness is a useful indicator of sepsis which may be masked by the use of analgesia. It is the author's belief that an initial course of NSAID analgesia is indicated if the horse is in pain. Once an accurate diagnosis is made then the horse should be given appropriate pain medication.

Chronic tracts invariably form pockets of necrotic material and more aggressive debridement is necessary for a successful outcome. The procedure can be performed standing with local anaesthesia of the digital nerves. The use of a hand held motorised burr (e.g. Dremel Tool) is invaluable in carefully removing the overlying horn (**Figure 6**). Care should be taken to preserve as much of the coronary band as possible and prevent subsequent defects in hoof wall growth.

Follow up treatment

Swabs moistened with diluted povidone iodine can be packed into the wound for the first few days but care should be taken to avoid overzealous use of any caustic agents as this can impair the development of healthy granulation tissue. Further applications of bandages and dry poultices over the following days will help avoid environmental contamination of the site and provide protection to the healthy granulation tissue that will subsequently form.

Acrylic resin can be used to fill extensive hoof wall resections but only after the underlying granulation tissue has been laid down in the base of the defect and the discharge from the tract has completely dried up, a process that normally takes four to six weeks. Premature defect filling is a risk as it can lead to escalating bacterial replication and thermal necrosis of the underlying tissue from the high temperatures generated during the curing process of the resin.

DEEP SOLAR PENETRATIONS

Presentation

Horses with deep penetrating wounds to the sole present in the same way as those with superficial injuries with a lameness increasing in severity with time, increased digital pulses with swelling of the distal limb and evidence of penetration on the solar surface of the foot may or may not be absent. For this reason, caution should always be taken when examining any solar penetration, especially those involving the middle third, as these will be more likely to involve vital deeper structure.

Radiography

As stated earlier, the ability to radiograph the foot with the offending object still in position provides the practitioner with the best visualisation of the depth and direction of the puncture, identifying any vital structures that may



Figure 7: Lateral radiograph showing contrast media correctly injected into the navicular bursa. No abnormal leakage of bursal contents has occurred.

have been penetrated en route.

If the object has already been removed, plain radiographs can be obtained to highlight any obvious changes such as associated fractures of the third phalanx or navicular

bone. A blunt, sterile, metal probe (e.g. Nasal swab) inserted into the tract or contrast media injected into the penetrating tract (Fistulogram) may be able to offer some idea as to the pathway of penetration. Injecting contrast media into the navicular bursa, coffin joint and digital sheath, will outline the limits of these synovial cavities and may identify a fistula communicating with the penetrating wound (**Figure 7**).

Synoviocentesis

Radiography should be supplemented by synoviocentesis of the navicular bursa, the distal interphalangeal joint and the digital tendon sheath as appropriate, with samples submitted for full cytological, bacteriological culture and sensitivity examination. Expect a mixed population of gram +ve, gram -ve and anaerobic bacteria to be introduced by heavily contaminated objects. The success of bacterial culture of samples from septic equine joints is disappointingly low – approximately 50 per cent. An attempt at culture and sensitivity should be repeated in chronic cases, as modifications to the antimicrobial regime may be necessary.

The retrieval of synovial fluid is not always possible,

especially from the navicular bursa. A latero-medial radiograph of the foot is advisable to determine accurate placement of the needle when synoviocentesis of the bursa is being carried out. If a sample cannot be retrieved, then injecting a few mL of sterile isotonic saline into the synovial structure and withdrawing this fluid will at least provide a small volume for a cytological examination and differential cell count. If the penetrating tract is still open, then injecting a larger amount of saline may result in leakage from the puncture wound.

Magnetic resonance imaging

Magnetic resonance imaging (MRI) has now become a referral diagnostic modality available in Ireland. MRI provides superior visualisation of the soft tissues, bone and fluid structures within the hoof capsule in both the standing, sedated horse and under general anaesthesia. It can be invaluable in assessing the damage from both an acute or chronic penetration (Figures 8 and 9). Indeed, in chronic wound penetrations where the entry point has since sealed over, MRI can reveal evidence of the localised inflammatory response present as a result of the puncture. Furthermore, the presence of a bone sequestrum can often be identified earlier on MRI than by radiographs which can result in appropriate treatment being instigated as early as possible and the horse can return to competition. Some of the lesions that can be diagnosed include:

- Tendonitis of the deep digital flexor tendon;
- Bony sequestrae of the third phalanx and navicular bone
- Osteomyelitis;
- Increase in signal

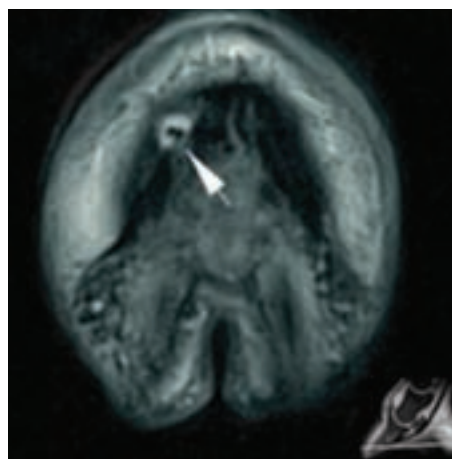
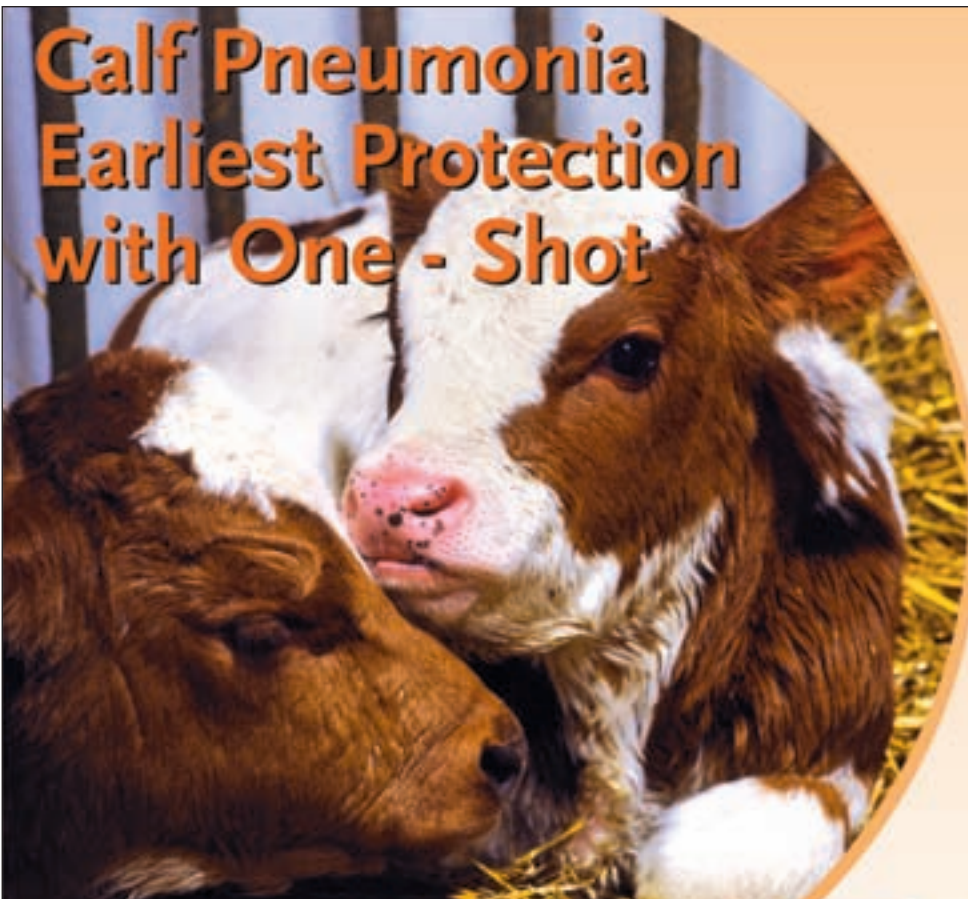




Figure 8. (Transverse STIR image of the foot) The white arrow denotes a sequestrum on the solar border of the pedal bone.

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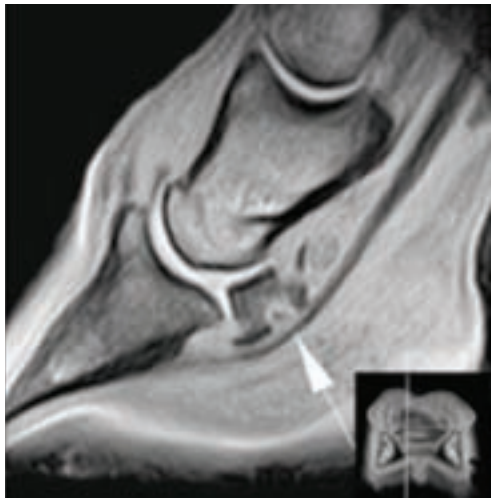


Figure 9. (Sagittal T2* weighted image of the foot) The white arrow denotes a focal area of necrotic bone within the navicular bone. The penetrating tract through the sole and deep digital flexor tendon could also be identified on MRI.

in fitting with bone oedema within the navicular bone;
and,

- Pathology of the impar ligament and the proximal suspensory ligament of the navicular bone

TREATMENT OF DEEP PENETRATIONS

The type of treatment required for a particular case will vary with the severity and duration of the penetration. Immediate referral to an equine hospital may be the best option for the more challenging cases. For serious penetrations (i.e. suspicion of a septic synovial or tendinous structure), broad-spectrum antibiotics such as benzyl-penicillin (10mg/kg bwt i.v. t.i.d.) and gentamicin sulphate (6.6mg/kg bwt i.v. s.i.d.) intravenously should be commenced immediately whilst further investigation of the lesion is carried out and/or one awaits the results of cytology. Arthroscopy of the coffin joint, navicular bursa and digital tendon sheath can all be performed and allows for evaluation of intra-synovial structures, debridement of lesions, removal of debris and foreign bodies and copious lavage of sterile saline through the synovial structures.



Figure 10: A horse shod with a raised heel in an attempt to reduce the pressure of the deep digital flexor tendon acting on the navicular bone.



Figure 11: An example of a hospital plate applied to a standard horseshoe. The sole now is being provided with excellent protection from the environment.



Figure 12: A previous lateral heel bulb laceration has created a permanent defect in the hoof wall.

POSTOPERATIVE CARE

Antibiotic therapy

Intravenous regional perfusion has been shown to be an effective method of establishing high concentrations of antimicrobials in the distal portion of the equine limb. This can be carried out daily or every other day. Intravenous regional perfusion is an adjunct to arthroscopic lavage and debridement and is not a sole alternative for treatment of synovial sepsis. Commonly used antimicrobials in intravenous regional perfusion are gentamicin sulphate, amikacin sulphate and ceftiofur. Systemic antibiotic therapy with benzyl-penicillin and gentamicin sulphate is necessary for a minimum of five to seven days.

Pain management

Following appropriate surgical and medical intervention, affected horses can still remain severely lame in the immediate post treatment period. Various forms of analgesia can be used but selection is usually made on a case-by-case basis. Phenylbutazone is still the most commonly used non-steroidal anti-inflammatory for orthopaedic pain in the pre- and post-operative period. Also, a combination of an opioid (e.g. morphine) with an alpha-2 agonist (e.g. detomidine) supplied via an epidural catheter has been found to be an effective method of analgesia of the hind limb.

Supportive farriery

Horses with damage to the navicular bone or deep digital flexor tendon, aid from being shod with a wedged heel on the effected foot (**Figure 10**). This helps to reduce the forces acting on the tendon as it courses around the flexor surface of the navicular bone. Solar support of the contra-lateral limb is also advised in the severely lame patient in an attempt to prevent laminitis. Hospital plates can be fitted where large defects in the hoof have been created by surgery. The advantages of providing rigid support to the weight-bearing surface of the foot, reducing environmental contamination of the solar defects and reducing the daily costs of dressing changes (**Figure 11**).

Wounds involving the coronary band and heel bulbs

Avulsion injuries of the coronary band and heel bulbs frequently occur following entanglement with wire. Disruption of the coronary band can lead to permanent disfigurement of subsequent hoof growth if left unattended (Figure 12). Exuberant granulation tissue rapidly forms due to the instability of the tissue. Following diagnostic procedures common to previous hoof injuries, wounds should be explored with a sterile glove and probe. Involvement of the collateral cartilages of the third phalanx can go on to result in chronic infection or 'quittor' and require surgical curettage for resolution. Furthermore, the clinician must be aware of the possibility of a foreign body lodging subcutaneously. An ultrasound examination of a wound is indicated, however, subcutaneous air pockets can often make a meaningful ultrasonographic examination difficult.

Treatment

Depending on the age of the wound, the level of organic contamination and the involvement of deeper structures,

every effort should be made to restore the normal anatomical alignment of the coronary band in a primary closure. This is not always possible and so a delayed primary or secondary closure is only achievable. The repair is best supported with the application of a foot cast up to the level of the distal fetlock for a duration of two to three weeks. Following removal of the cast, healthy granulation should be kept clean with regular bandage changes until such time that the skin edges have closed over.

SUMMARY

In summary, penetrations of the horse's foot should always be treated with caution. A radiographic examination of the foot with the offending object still present gives the clinician the best idea as to the orientation and depth of penetration. Most importantly, it will allow for an assessment of what structures could potentially be involved. MRI of the foot will provide superior imaging for both recent and longer standing cases. Instigating appropriate therapy promptly will more likely result in the successful resolution of a case of solar penetration.

CONTINUING EDUCATION: QUESTIONS AND ANSWERS**Q1. WHICH OF THE FOLLOWING SYNOVIAL STRUCTURES IS LEAST AT RISK FROM BEING PENETRATED BY AN OBJECT ENTERING THE SOLE?**

- A. The navicular bursa
- B. The distal interphalangeal joint
- C. The digital tendon sheath
- D. The proximal interphalangeal joint

Q2. WHICH OF THE FOLLOWING STATEMENTS IS FALSE?

- A. Clinical signs alone should not be used as a means of distinguishing between superficial and deep solar penetrations as they frequently overlap.
- B. Always check the tetanus vaccination status of the patient is up to date.
- C. Instant removal of the foreign object by the owner is always advisable to limit further trauma and make a diagnosis easier.
- D. Horses with a penetrating injury into a synovial structure may or may not be weight bearing in the initial post injury period.

Q3. WHICH OF THE FOLLOWING PATHOLOGICAL CONDITIONS OF THE FOOT SUBSEQUENT TO A SOLAR PENETRATION CAN BE HIGHLIGHTED USING STANDING MRI?

- A. Bone sequestrae of the coffin and navicular bones
- B. Bone oedema of any osseous structures
- C. Desmitis of the proximal suspensory ligament of the navicular bone
- D. All of the above.

Q4. WHICH OF THE FOLLOWING STATEMENTS REGARDING DEEP WOUNDS IS INCORRECT?

- A. Affected horses will often be sore to hoof tester pressure applied across a generalized area of the sole.
- B. Failure to retrieve synovial fluid from the navicular bursa or coffin joint indicates an absence of infection.
- C. Radio-opaque contrast injected into any identified draining tracts can be useful in assessing the depth and direction of penetration.
- D. Increased digital pulses and swelling of the coronary band may be seen with both deep and superficial puncture wounds.

Q5. REGARDING THE TREATMENT OF PUNCTURE WOUNDS, WHICH OF THE FOLLOWING STATEMENTS IS INCORRECT?

- A. If acrylic resin is to be used to fill in hoof wall defects, then it is important to wait until after a healthy bed of granulation tissue has formed otherwise there is a risk of aggravating the condition.
- B. Endoscopy of the coffin joint, navicular bursa and digital tendon sheath can all be performed and increase the likelihood for a success outcome if any of the structures are involved.
- C. Establishing drainage for superficial puncture wounds is often curative
- D. Concentrated iodine soaked swabs encourage the development of healthy granulation tissue.

Answers: 1:D 2:C 3:D 4:B 5:D