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Surgical Treatment of Equine Foot Disorders

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Introduction

The equine foot is a common site of lameness and is prone to injury because of its location and the forces it is exposed to associated with locomotion. Consequently, there is an array of surgical procedures involving the foot of the horse. Foot injuries include puncture wounds, lacerations, and hoof wall avulsions. Puncture wounds to the sole of the foot tend to close and trap bacteria and debris resulting in infection. Therefore, these wounds may result in foot abscess, septic osteitis of the coffin bone, septic coffin joint arthritis, or septic navicular bursitis depending on the location of the wound. Lacerations to this area often involve the coronary band or heel bulb. This could have an impact on normal hoof wall growth. Underlying structures such as the distal interphalangeal joint, collateral cartilage of the distal phalanx, extensor or flexor tendon may be traumatized as well and become infected. Review of all the surgical approaches to the equine foot is beyond the scope of this presentation. This presentation will primarily focus on the surgical treatment of traumatic injuries to the foot including secondary septic processes, but will also cover palmar digital neurectomy and keratoma excision. The author acknowledges that surgical treatment of these conditions will vary among practitioners, but presents information based on literature review and experience.

Anatomy of the Foot

There are several structures deep to the hoof wall (Fig. 1). This includes the boney structures, the distal phalanx, navicular bone (distal sesamoid bone) and distal end of the middle phalanx. Tendon structures in the foot of horses include the common or long digital extensor tendon of the front or rear leg, respectively, which insert on the extensor process of the distal phalanx. The deep digital flexor tendon runs palmar/plantar to the bone structures and inserts on the solar surface of the distal phalanx. The distal phalanx is also held in position by lateral collateral ligaments. The navicular bone is supported in position by ligaments proximally and distally. The medial and lateral collateral suspensory navicular ligaments attach to the proximal border of the navicular bone and travel abaxially to insert on the distal region of the proximal phalanx. The distal sesamoidean impar ligament attaches to the distal border of the navicular bone and travels distally a short distance to insert on the solar surface of the distal phalanx.

Synovial structures of the equine foot include the distal interphalangeal joint, navicular bursa and distal portion of the flexor tendon sheath. The navicular bursa is situated between the flexor surface of the navicular bone and deep digital flexor tendon. The impar ligament separates the navicular bursa from the distal palmar/plantar pouch of the distal interphalangeal joint. Contrast studies have shown that no communication exists between the distal interphalangeal joint and
navicular bursa.\textsuperscript{2} Other structures include the medial and lateral ungual cartilages or (collateral) cartilages of the distal phalanx. These cartilages tend to be fibrocartilagenous in adult horses and may ossify.\textsuperscript{1} The digital cushion is a highly modified subcutis that is positioned beneath the frog of the sole. Finally the hoof wall and sole are held by laminar attachments.

![Figure 1. Anatomy of the foot.](image)

Preparation of the Equine Foot for Surgery

There are certain procedures that aseptic principles should be followed when performing surgery on the horse's foot, i.e. endoscopy of the navicular bursa. For all surgical approaches preparation of the hoof and sole is necessary. I prefer to have the foot prepared a day prior to surgery. The shoe is pulled, if present, and the hoof wall trimmed. The sole including the sulci and frog are pared out as much as the tissue will allow without causing bleeding and all dirt and debris removed. The foot is thoroughly scrubbed with a disinfectant scrub such as 10\% povidone-iodine solution\textsuperscript{a}. Then the sole is packed with surgical sponges soaked in a disinfectant and secured in place by wrapping the foot with a self-adherent elastic bandage wrap.\textsuperscript{b} At the time of surgery, the wrap is removed and the foot is aseptically prepared.

Peri-Operative Considerations of the Patient

Most of the foot disorders or injuries to be discussed are best treated using \textit{general anesthesia}. Foot abscesses, hoof wall injuries, and superficial coronary lacerations can be treated using local perineural anesthesia (palmar nerve block at the level of the abaxial surface of the proximal sesamoids). Third phalanx sequestrectomies may also be treated using local perineural
anesthesia, though I prefer general anesthesia from the aspect of being able to establish better hemostasis intra-operatively.

Hemostasis is a very important consideration intra-operatively with procedures that involve debridement and/or excision on the equine foot. It is important that a tourniquet be utilized to limit hemorrhage during debridement to keep the surgical field clear to allow a more thorough and accurate surgical treatment. There are different types of tourniquets that can be used, but my preference is a pneumatic tourniquet. Better control of the vascular occlusion can be achieved compared to an elastic tourniquet. The pneumatic tourniquet is pressured to 600 mmHg or 12 PSI to get adequate compression of the vessels in the limb. If a pneumatic tourniquet is not available, an elastic band can be used. The tourniquet is positioned at mid-metacarpus/metatarsus, with a gauze roll and is placed over the vascular bundle, medially and laterally under the tourniquet.

Antimicrobial therapy is recommended for the injury related foot disorders, because of the environment of the foot. Superficial type of injuries, such as lacerations, hoof wall injuries, or septic pedal osteitis can be managed with oral antimicrobial therapy such as trimethoprim/sulfamethoxazole at 25 mg/kg, q 12 h, PO. For more serious injuries that involve underlying structures such as synovial cavities, tendons, or ligaments, broad spectrum antimicrobial therapy should be considered. I recommend the combination of potassium penicillin at 22,000 IU/kg, q 6 h, IV and gentamicin at 6.6 mg/kg, q 24 h, IV. The duration of antimicrobial therapy depends on the response of the horse to treatment, but typically 14 days. If longer antimicrobial therapy is needed then I will continue with chloramphenicol at 50 mg/kg, q 6 h, PO.4

In addition to systemic antimicrobial therapy, I will also employ local therapy and regional intravenous limb perfusion. Surgical debridement or excision of a wound in this region which cannot be closed, I will pack with a disinfectant along with 1 gram of metronidazole. This is performed by crushing the metronidazole tablets and mixing with 10% povidone-iodine solution to a paste consistency. The packing is replaced daily. Oral or rectal administration of metronidazole can be considered and although no work has been done to investigate the concentrations, I prefer local application.5 Another adjunct antimicrobial therapy that is effective in delivering high MIC levels to the distal limb is regional limb perfusion of antibiotics (RILP).6 RILP entails sedating the patient and placing a tourniquet at mid-metacarpus/metatarsus. The area over of a peripheral vein distal to the tourniquet (i.e. palmar vein along the abaxial surface of the proximal sesamoid) is aseptically prepared and catheterized with a 22-gauge butterfly catheter using aseptic technique. The antibiotic is diluted in 15 ml of saline and infused over a period of 1 minute (Fig. 2). Once infused, the catheter is pulled and a small bandage is placed over the area. The tourniquet is then left in place for 20 minutes. Regional limb perfusion of antibiotics is performed once daily for 3 to 5 days. In most cases, either 1 gram of cefazolin or 750 mg of amikacin is infused.

It is also important that pain management be employed with surgery of the deep structures. Contralateral supporting limb laminitis is a concern. Steps should be made to provide prophylactic treatment. Pain management includes use of non-steroidal anti-inflammatories at recommended dosages. Epidural anesthesia has also been utilized for hindlimb foot injuries.
Foot Disorders and Surgical Procedures

Foot Abscesses

There are generally three locations of a foot abscess: subsolar, white line, or heel bulb. Environment can play a role in the development of a foot abscess. Dry weather followed by a period of wet weather may result in development and an undetected crack in the hoof wall and migration of debris along the crack resulting in an abscess. In some cases, subsolar bruising may result in a foot abscess. As the name implies, subsolar abscesses occur beneath the sole of the foot, usually the quarters or toe region. Gravel is an abscess along the white line. Heel bulb abscesses generally involve the sensitive tissue of the heel bulbs. Gravels and heel bulbs often spontaneously break open and drain at the coronary band. Gravels particularly, will migrate up the white line (Fig. 3).

Treatment

There are several ways in which foot abscesses can be treated. My preference is to soak the foot with a mixture of warm water, magnesium sulfate crystals, and 10% povidone-iodine solution.
after which the foot is wrapped with a dressing medicated with ichthammol and magnesium sulfate crystals. Once a subsolar abscess has matured it can readily be located with hoof testers and pared out. Then it is flushed with a 50:50 mixture of hydrogen peroxide and 10% povidone-iodine solution. The goal is to dry the abscess. To accomplish this I like to use a foot packing with a strong iodine solution. The packing is wrapped in either a commercial boot or duct tape. Once the abscess is dry and no longer draining, a shoe with a sole pad is placed on the foot to protect the sensitive tissue of the pared area. Paring is usually not needed with gravel or heel bulb abscesses and they do not usually require bandages. On occasion, resection of the cornified hoof at coronary band may be necessary for gravels. The sensitive tissue underneath can become compressed by the hoofwall and obstructing drainage or causing discomfort. Local anesthesia may be needed in some cases and the large scalpel is used to excision the hoof wall at the lip of the opening of the abscess.

**Septic Pedal Osteitis**

Septic pedal osteitis is a septic process involving the distal phalanx. Sequestration of bone often occurs. In most instances, septic pedal osteitis is a result of a puncture wound to the solar surface of the foot. Septic pedal osteitis with bone sequestration is diagnosed using radiography in which a sequestrum is seen along the edge of the distal phalanx (Fig. 4).

![Figure 4](image-url)  
**Figure 4.** A 65° dorsal to palmar radiograph of P3 with septic pedal osteitis. Note the sequestrum along the edge of P3 (arrow).

**Treatment**

Surgical debridement is best performed under general anesthesia, although local anesthesia and sedation can be used. The hoof is prepared for surgery as previously described. A tourniquet is applied and the hoof wall is carefully pared away to expose the sequestrum using a conventional hoof knife that has been disinfected. In most cases a draining tract can be followed down to the
sequestrum. If not, radiographic control should be used to locate the sequestrum. Once the distal phalanx has been debrided, the defect is packed with a medicated pad and a wrap applied. For long-term coverage of the sole, a medicine plate shoe works well (Fig. 5). A medicine plate is a bar shoe that is drilled and tapped at the heels and toe to receive a 7/16 th inch bolt. A plate (constructed from aluminum) is cut to the shape of the shoe and attached to the bottom of the shoe. The bolts can easily be removed and the medicated packing changed on a regular basis (daily). Packing of the wound is continued until granulation tissue forms and keratinizes. Systemic and local antimicrobial therapy is administered.

Figure 5. Medicine plate shoe

Quittor

Quittor is defined as a chronic septic necrosis of a collateral cartilage of the distal phalanx. The cause of quittor in most cases is a penetrating wound or laceration at the coronary band region (Fig. 6). Clinical signs include, swelling, a chronic fistulous tract, usually at the lateral or medial region at the coronary band, and a variable degree of lameness. The wound often has a foul odor. If the wound is chronic, radiographic changes may be evident, including soft tissue swelling at the coronary band, fistulous tract, and lysis of the collateral cartilage (Fig. 7). There may be indication of joint involvement with bone lysis and collapse of the joint space.
Treatment

Surgical debridement is usually necessary. This entails general anesthesia with the horse positioned in lateral recumbency with the affected area facing upward. The hoof and region is prepared for surgery. A tourniquet is applied which is very important. An incision is made just proximal to the coronary band and the skin is reflected axially. If granulation tissue is present, it is resected along with the involved portion of the collateral cartilage (Fig. 8). It is very important that meticulous dissection is performed to prevent entry into the coffin joint which lies just axial to the cartilage. The foot is held in maximal extension during dissection to tighten the joint capsule to minimize accidental penetration of the joint.8 If deep dissection is necessary within the hoof wall, then a hole is placed in the wall of the hoof, just distal to the surgical site, to establish drainage. This can be performed manually by using a large drill bit fitted in a wooden rasp handle. Any reflected skin is anchored down with sutures.

![Figure 8. Post-op resection of a septic collateral cartilage. Closure was not attempted.](image)

If the surgical wound cannot be sufficiently closed, packing with a topical antibiotic and metronidazole/povidone-iodine paste and a firm heavy bandage is recommended. Systemic antibiotics are also recommended. A bandage should be maintained over the wound and changed daily until sutures are removed or granulation tissue has filled the defect and is covered with epithelium. A foot cast can be used in place of a bandage once the wound has granulated in. The prognosis for horses with quittor is fair if caught early enough. However, if the infection is chronic, then this obviously creates a less favorable prognosis due to the tissue destruction. The prognosis is poor if the distal interphalangeal joint, digital cushion, or bone is involved.

As an alternate therapy, maggot debridement has been used.9 Maggots selectively digest primarily the necrotic tissue allowing for ingrowth of healthy granulation tissue. Sterile maggots are bred specifically for ‘biosurgery’. A single maggot is reported to consume up to 75 mg of necrotic tissue per day.9 Maggots are applied to the wound at a density of five to eight per square
centimeter. A hole matching the wound dimension cut into a self adhesive hydrocolloid dressing keeps the maggots in place. The dressing is covered by a pad of light gauze and replaced every 4 to 8 hours to remove exudate. Maggots are applied for two 48-hour cycles each week.

**Septic Navicular Bursitis (Street Nail Injury)**

Septic navicular bursitis almost always occurs as a result of a wound by a sharp foreign body, such as a nail, that has penetrated through the frog and into the navicular bursa. Severe lameness develops once the infection becomes established. Navicular bursa involvement should be suspected if a sharp or pointed object has penetrated into the area of the frog. Diagnosis is made by radiography of the foot (lateral views) with the foreign body in place (Fig. 9). If the foreign body appears to be immediately adjacent to the navicular bone, then there is a high probability that the navicular bursa has been penetrated. However, diagnosing septic navicular bursitis can be difficult if the penetrating foreign body is not present at the time of inspection. It is recommended to perform a contrast study by placing a small cannula into the wound and infusing a radio-opaque dye into the wound and immediately taking a lateral radiograph of the foot to confirm communication. In the case of a navicular bursa involvement, the contrast will outline the bursa (Fig. 10).10 If the foreign body has penetrated the distal interphalangeal joint, the contrast will outline the joint cavity as well. This is not an uncommon finding as the impar ligament may be penetrated.

![Figure 9. Field radiograph of the foot of a horse with a nail penetrating the sole. Notice the point of the nail near the navicular bone.](image1)

![Figure 10. Contrast study of a foreign body penetration of the frog of a horse’s foot.](image2)

**Treatment**

Treatment can be quite involved depending on the chronicity and the degree of infection. In acute cases, endoscopic inspection of the navicular bursa is recommended.11-13 This entails general anesthesia with the horse positioned in lateral with the affected limb uppermost or dorsal recumbency. The hoof and pastern are prepared for surgery as previously described. The arthroscope is entered into the bursa through an incision made just proximal to the lateral
collateral cartilage and adjacent to the abaxial edge of the DDF tendon, avoiding the palmar digital neurovascular bundle dorsally. An instrument portal can be created using the same approach on the contralateral side of the limb. Any foreign debris is removed.

In chronic cases, endoscopic inspection is also recommended, but establishment of drainage may be necessary if infection is evident (extensive fibrin, tissue necrosis and debris within the bursa). This is performed by creating a window through the frog. A tourniquet is applied (which is very important) prior to surgery. A window is cut in the middle third of the frog and digital cushion using sharp incision. A powered oscillating saw can be used to excision the frog. The window is extended through the deep digital flexor tendon and bursa. The navicular bone is readily identified (Fig.11). If a tract is present, it can be used as a guide to the navicular bursa.

Regardless of the approach, the bursa is copiously lavaged with sterile polyionc solution under pressure. Three to five liters is recommended. A needle should be placed into the distal interphalangeal joint to determine if there is involvement by the escape of fluid through the needle. As an alternative, the navicular bursa can be lavaged through placement of a needle into the bursa. Intra-bursal injection of an antimicrobial (amikacin, 750 mg or cefazolin, 1 gm) post lavage is also recommended.

![Image](https://via.placeholder.com/150)

Figure 11. A navicular bursotomy was performed for a septic navicular bursitis. The flexor surface of the navicular bone has been exposed.

Post-operative follow-up treatment includes regional limb perfusion of antimicrobials, systemic antimicrobials and anti-inflammatory medication. Depending on the severity of the injury, lavage may be repeated with the horse under general anesthesia. If a bursotomy was performed, the wound is packed with metronidazole/povidone-iodine paste with a heavy foot bandage. A medicine plate is applied to the foot for long term care. The prognosis for soundness is guarded-
to-grave, depending on the chronicity of the infection.\textsuperscript{11,18} As a general rule, the sooner the treatment, the better the prognosis for soundness.

**Coronary Band and Heel Bulb Lacerations**

Coronary band and heel bulb lacerations often occur due to the foot being caught in a stationary object such as a fence or under a stall door or possibly from a sharp-edged object such as the metal siding on a building (Fig. 12). Inspection of the wound for deep structure involvement is important. Deep structure involvement (i.e. distal interphalangeal joint, lateral cartilages, collateral ligaments) could have a serious impact on the prognosis for soundness.

**Treatment**

These types of injuries are best treated with primary closure when possible and the application of a cast. This approach would also be appropriate for chronic lacerations. Advantages of casting heel bulb and coronary band lacerations are that the cast reduces motion and gaping of the wound, physically impedes exuberant granulation tissue formation thus providing the best cosmetic and functional end results. Obviously, the situation will dictate whether or not general anesthesia or local sedation is appropriate, but in most cases, general anesthesia is preferred. In general, wounds can be managed by primary closure, delayed closure, or second intention healing. Several factors dictate with approach including the amount of skin loss, duration of wound, and amount of contamination.\textsuperscript{19}

\textbf{Primary closure} can be performed if the laceration is acute, clean, tissue loss is minimal. \textbf{Delayed primary closure} (2 to 3 days after injury) is recommended if an acute laceration is excessively contaminated or if there is uncertainty whether underlying structures are involved. \textbf{Delayed secondary closure} is also recommended for older lacerations with granulation tissue.

The foot is prepared with a light bandage placed over the wound to prevent contamination. The wound is cleaned, thoroughly debrided and explored to determine if any deep structures are
involved. If so, then a more aggressive course of action will be needed to prevent or reduce chances of infection, such as broad spectrum systemic antimicrobials, regional limb IV perfusion of antimicrobials, and joint lavage (if involved). The hair is clipped from around the wound and then the wound is meticulously scrubbed with a disinfectant. This is followed with thorough lavage of the wound using a diluted povidone-iodine solution (10ml/liter of saline) or chlorhexidine solution (25ml/liter saline). The wound edges are freshened and closure is performed. When freshening the wound edges, it is important not to trim skin away but to use the edge of the scalpel blade and scrape the skin edges until there is acceptable hemorrhage present. This will reduce loss of tissue which will complicate the closure. With delayed closures, it is imperative that as much of the granulation tissue be excised prior to closure. Otherwise dehiscence due to continued growth of the granulation tissue inside the wound will occur. A tourniquet is utilized to minimize bleeding during excision of the granulation tissue. One of the key points to keep in mind when closing a coronary band wound is to maintain as much alignment and apposition of the tissues as possible (Fig. 13). This will reduce abnormal hoof growth.

Once the wound has been debrided and closed if possible, a topical antibiotic ointment is applied and a light, non-adherent dressing is placed over the wound and a foot cast is applied (Fig. 14). I apply the foot cast in a similar manner as a conventional cast, using an orthopedic stockinette and custom support foam padding under the cast. A strip of orthopedic felt is placed around the pastern where the top of the cast will stop. During application of the cast, it is important to position the foot in a near-normal standing position in relation to the body. This will allow the horse to walk more comfortably in the cast. Once the foam and felt are in position, then the fiberglass cast material is applied. I prefer to use 3-inch rolls (3-4 rolls) which allow easier manipulation over the contours of the foot and pastern. The cast is applied so it extends to just below the fetlock joint to prevent impingement during flexion and extension of the joint. The proximal half of the strip of orthopedic felt is left exposed above the cast material. This will protect the underlying soft tissue along the top of the cast. The bottom of the cast is capped with an acrylic applied on the walking surface to prevent excessive wear. The top of the cast is sealed with an adhesive flexible tape to prevent debris from working down inside the cast.
In most cases, the foot cast is left on for 14-21 days. For acute lacerations in which closure was possible, the cast is maintained for 2 weeks. If delayed closure was performed or the wound could not be closed, then the cast should be left on longer to allow time for epithelialization and contraction of the wound. This could take as long as 4 weeks. In these cases, the cast should be changed at 2 week intervals to inspect the progress of wound healing and surrounding region for cast sores.

**Hoof Wall Injuries**

Hoof wall injuries occur in varying degrees. This includes vertical tears, usually at the quarter or heel, and subtotal avulsions (Fig. 15). These generally occur when the horse steps on a sharp stationary object. Often the sole is involved as well. The amount of deep structure involvement or extent hoof wall loss will dictate the outcome. These types of injuries usually take a prolonged period of time to heal. Most of these injuries are repairable unless there is a significant loss (greater than 50%) of the hoof wall. In these cases, then euthanasia is strongly recommended.

![Figure 15. Hoof wall avulsion injury.](image)

**Treatment**

If the coronary band and underlying hoof wall corium are still intact, then the hoof segment is reattached. Maintaining alignment of the opposing hoof walls during reconstruction will aid in normal regrowth of the hoof wall. If a hoof segment has been avulsed from the underlying dermal lamina then the best approach is to completely remove the segment. Treatment can be performed with local anesthesia and sedation or general anesthesia depending on the nature of the patient. The foot and surrounding area is prepared for surgery. If the segment is being reattached, special attention is given to the cleaning and debridement of the wound. Reconstruction can be accomplished by lacing across the defect using different materials, including nails, flexible metal plates and screws, suture material or wire. The laceration is
sutured if it extends proximal to the coronary band. If the segment of hoof is lost then the wound will have to heal by second intention.

Once the wound has been addressed, topical antibiotic and a light bandage is applied. I find it very effective to apply a foot cast to these types of injuries (Fig. 16). It may take an application of two foot cases at three-week intervals to get enough hoof wall growth at the coronary band before casting can be discontinued. By this time, any underlying tissue will be keratinized if hoof was lost. Other adjuncts treatments include patching across the injury, though infection under the repair is a risk, and application of a bar shoe with clips. At some point a bar shoe is used in almost all cases. If the avulsed hoof segment is left intact, the sole surface of it is reduced so that it is ‘floated’. This will reduce the shear forces along the avulsion line. There are a variety of acrylic or urethane materials available that are strong, durable and quite effective in keeping the hoof wall stable.

Figure 16. Hoof wall avulsion injury. The hoof wall was laced with large suture and a cast was applied. Notice that the heel of the avulsed segment was floated.

**Chronic Heel Pain**

Chronic heel pain is a condition in horses that exhibit reoccurring lameness that has been ‘isolated’ to the caudal third of the foot. Some of the factors that predispose a horse to developing chronic heel pain include breed (Quarterhorse and Thoroughbred), poor foot conformation such as underrun heels, athletic activity causing repeated trauma, and broken back hoof pastern axis. The cause is multi-factorial although navicular syndrome has drawn the most attention. It is beyond the scope of this paper to discuss the etiologies and diagnostic approaches in depth, but arriving at a diagnosis is important in determining what avenue is best taken for treatment.

**Treatment**

Numerous ways of treating chronic heel pain has been previously described. Surgically, a palmar digital neurectomy is considered when all other forms of treatment have been exhausted. Various techniques have been described for performing a palmar digital neurectomy. The
procedure can be performed standing; however, it is best done under general anesthesia. The foot and surrounding area is prepared for surgery. I prefer to use the two-incision technique and transaction of the nerve with a laser. Two incisions (2 cm in length) are made along the medial & lateral edge of the deep flexor tendon, in the proximal and distal pastern region. (Fig. 17). In each of the incisions, the nerve is identified just palmar to the digital artery, approximately 1 cm below the skin surface and deep to the ligament of the ergot.

![Figure 17. Illustration showing the two-incision technique made in the skin to perform a palmar digital neurectomy.](image1)

The nerve is isolated by blunt dissection and lifted from the incision with a pair of mosquito forceps (Fig. 18). Once the nerve is freed from its subcutaneous attachments between incisions, the nerve is grasped through the distal incision, stretched and transected as distally as possible using a CO2 laser. The nerve is then pulled through the proximal incision, stretched and transected proximally as possible in the same manner. As an alternate method the nerve can be transected with a scalpel using the guillotine technique.

![Figure 18. The palmar digital nerve is carefully dissected from the subcutaneous tissues, elevated from the incision and stretched to perform a neurectomy.](image2)
Closure consists of a subcuticular suture (2/0 absorbable). Skin sutures are optional. A sterile dressing with pressure bandage is maintained for 21 days along with non-steroidal anti-inflammatory therapy. Resumption of work is not recommended until 30 days post-surgery.

Local nerve block has been advocated to decrease pain associated with the surgical procedure, to decrease the depth of general anesthesia required to avoid movement, and to improve recovery from anesthesia. Neuroma formation is a potential sequela of a palmar digital neurectomy. Various procedures have been described in an attempt to prevent neuroma formation and digital reinnervation. In one study, after sharp palmar digital neurectomy, CO₂ laser energy was applied to the proximal nerve stump. Of the 10 horses in the study none had clinical evidence of painful neuromas or digital re-innervation. In my hands the use of CO₂ laser has reduced the formation of neuromas.

**Keratoma**

A keratoma is a benign keratin-containing mass that develops between the hoof wall and the underlying distal phalanx. Their occurrence is rather uncommon. Keratomas result from proliferation of cornified tissue on the inner surface of the hoof wall, which often originates near the coronary band. Keratomas can appear elongated or as a spherical entity. Most keratomas are found in the dorsal aspect of the wall in the toe or quarter region. Some may extend to the solar surface of the foot at the white line. The etiology is not clear but believed to be due to chronic inflammation or trauma. Due to the expansive nature of a keratoma, there is visible bulging of the hoof wall with lysis of the underlying distal phalanx. Lameness and reoccurring abscessation may occur.

Keratomas are diagnosed by physical evidence of displacement of the white line toward the sole and focal lysis of the distal border of the third phalanx (Fig. 19). Ultrasonography can be used if bulging is located near the coronary band. A circular shadow is noted, which is suggestive of a keratoma.

![Figure 19. Dorsal-palmar radiographic projection of the third phalanx. Focal area of lysis at the dorsal margin of the distal phalanx is suggestive of a keratoma.](image-url)
**Treatment**

Surgical treatment can be problematic as regrowth may occur. The keratoma must be completely removed to prevent regrowth. A keratoma can be removed in a standing patient but general anesthesia is recommended. Surgical enucleation entails first preparing the hoof for surgery as previously described. A tourniquet is applied to control hemorrhage. The hoof wall over the keratoma is taken down as much as possible with a rasp or a dremel tool fitted with a tungsten or carbide burr. Careful dissection is performed to remove the keratoma and surrounding tissue. An alternate method involves complete resection of the overlying hoof wall to expose keratomas that extend from the region near the coronary band to the sole. The resulting defect in the hoof wall is packed with metronidazole/povidone-iodine paste under gauze sponges. A sterile bandage is applied and maintained for the next 2 to 3 weeks or until keratinization of the underlying tissue occurs.

Stabilization of the hoof wall will be necessary during the time the hoof wall defect is healing and regrowing. Depending on the amount of hoof wall removed, bar shoe with clips may be sufficient. This is accomplished by applying a shoe with wide clips positioned on either side of the resected defect. This will reduce the independent movement of the two portions of the hoof wall. With more extensive hoof resection, further stabilization can be achieved by attaching a small metal plate to the hoof wall with short sheet metal screws.

Once regrowth of the hoof wall is complete, the prognosis is excellent for resolution of lameness and return to intended use.

**Discussion and Take Home Messages**

The anatomy of the foot is rather complex and wounds involving structures underlying the hoof wall, sole, or skin may have a serious negative impact on the prognosis for soundness. Puncture wounds to the frog region is of most concern which as discussed, may involve the navicular bursa. More cranial penetration of the frog may result in involvement of the distal pouch of the distal interphalangeal joint. The take home message is that thorough investigation of these wounds is imperative to determine the aggressiveness of treatment to prevent sepsis resulting in debilitating arthritis or bursitis.

Hemorrhage control is essential during surgical treatment of disorders of the foot. A tourniquet should be utilized to limit hemorrhage during debridement to keep the surgical field clear. The take home message is that hemostasis will allow a more thorough and accurate surgical treatment.

Perioperative planning is also important. System antimicrobial therapy along with local treatment, such as regional intravenous limb perfusion should be considered to establish high MIC levels of antibiotics. Thorough lavage of involved synovial structures is necessary to improve outcome if involved. Anaerobic infection is always a consideration when dealing with wounds of the foot and use of local metronidazole therapy is recommended. The take home message is that local as well as system antimicrobial therapy will improve the outcome.
References and Footnotes


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