

Delayed closure

Delayed closure combines healing by primary intention with healing by secondary intention and is sometimes selected as an approach to wound management when suturing an acute wound puts that wound at high risk of infection and subsequent dehiscence. To perform delayed closure, the wound is cleansed and observed for a few days, and after determining that it displays no signs of infection, the wound is sutured. Delayed closure may be performed after several days of open wound management, before granulation tissue has formed (referred to as “delayed primary closure”), or it can be performed after granulation tissue has formed (referred to as “delayed secondary closure”). Studies in rats have shown that healing and gain in tensile strength are not significantly postponed by closure after a moderate delay (3–5 days),³⁵ and meta-analyses of the human medical literature suggest that delayed primary closure may reduce the likelihood of infection at the surgical site of sutured contaminated and dirty incisions, though no such data concerning horses are available.^{6,7}

Delayed primary closure

Delayed primary closure is considered a suitable approach to manage a wound that is heavily contaminated or where the injured tissues are excessively swollen due to the extent or nature of trauma suffered at the time of wounding. A common example in the horse is a wound caused by crushing (e.g., trapping of a limb between boards or railings). Wounds with a contaminated synovial cavity are often best managed by delayed primary closure to provide the time required to re-sterilize the synovial cavity (e.g., via joint lavage and the administration of appropriate antimicrobial drugs, either systemically, regionally, and/or intrasynovially) prior to closing the wound.

The main disadvantage of postponing primary closure is that delay results in the temporary expansion of the wound’s surface area. This expansion, which usually lasts 7–14 days in horses, may impede suturing of the wound, thereby necessitating healing by second intention.

After the wound is cleansed and debrided, it is dressed and bandaged appropriately until it is deemed ready for suturing. Because primary closure is deferred due to the probability of infection and consequent wound dehiscence, dressing and bandage materials are selected according to their ability to manage contamination and control infection (the reader is referred to Chapter 6 for more information regarding wound dressings). Bandages should be changed daily or on alternate days so that the wound can be periodically debrided, if necessary, and so that the wound’s readiness for closure may be closely monitored.

To counter retraction of the wound’s edges during this “waiting period,” skin sutures may be placed to span the wound (from one edge to the other), thereby holding the edges loosely in place. In spite of this effort, many wounds are not entirely amenable to primary closure after a delay of several days.

If delayed primary closure is selected as the approach to manage a degloving injury in the metacarpal/metatarsal area, loosely tied sutures should be placed through the skin adjacent to the wound. These sutures draw skin over the wound to serve as a temporary biologic bandage, which reduces desiccation of underlying structures (e.g., bone and/or tendon) that would otherwise be exposed, and limit retraction of the wound’s edges. Rather than placing temporary sutures to manage the wound by delayed primary closure, the veterinarian should consider closing the wound primarily if contamination can be eliminated through debridement and the establishment of ventral drainage.

Tip

- In the case of an injury that has caused substantial blood loss, and perhaps shock (e.g., a heel bulb laceration that has severed a digital artery or a large wound to the body (Figure 8.6), managing the wound by delayed primary closure allows the patient’s systemic status to improve and stabilize prior to closing the wound. The basic principles of cleansing and bandaging apply, and the wound is closed when the systemic status of the horse has improved and stabilized.

The wound is prepared for closure after the wounded tissues are no longer edematous and the risk of infection has diminished in response to appropriate management of contamination. Clinical judgement is the most practical way to determine the point at which the wound can be closed, although quantitative methods, if available, may be used to measure the wound’s bacterial load. The wound should appear healthy, swelling should be minimal, and discharge should be clear, serous, and non-odoriferous. The wound is closed in much the same way as for primary closure. The horse is anesthetized, or the wounded region is desensitized by using local or regional anesthesia administered after the horse is sedated. The hair is clipped from the skin surrounding the wound, and the skin is scrubbed with an antiseptic soap. The wound may require a new round of debridement and the wound’s edges often must be undermined slightly to mobilize skin. Sutures are used to appose the tissues, as with primary closure (Figure 8.6c). Often, when the wound is managed by delayed closure, the wound can be only partially closed as a result of the skin retraction that occurs during the first few days after wounding. Nevertheless, partial (delayed) primary closure is preferable to forcing the entire wound to heal by second intention, for the reasons enumerated previously.

Delayed secondary closure

Delayed secondary closure is carried out on a wound healing by second intention after a healthy bed of granulation tissue has formed. At this point, the wound is revised, and granulation tissue is trimmed or debulked, if required, to allow apposition of the wound’s edges, often with the use of a tension-relieving suture pattern (Figure 8.7). If partial resection of the granulation tissue creates a dead space, a drain should be placed to prevent



Figure 8.6 (a) Example of a wound in which primary closure was deferred due to the patient's compromised systemic status (i.e., shock requiring administration of fluids and a blood transfusion) and contamination of the wound with hair and soil. The wound was irrigated daily, dressed with honey, and bandaged. (b) Delayed primary closure was undertaken 2 days after injury, after the horse's systemic status had improved and stabilized. The flap has been debrided and is being irrigated with polyionic fluids. (c) A horizontal mattress suture pattern, in combination with stents made of plastic tubing, has been used to close the wound. In an effort to ensure adequate drainage of fluid produced by the wound, a passive drain (Penrose tubing) and an active drain (homemade with a syringe) have been placed, and the most ventral portion of the wound has been left unsutured. A simple approximating or everting suture pattern is commonly used, in addition to the mattress tension sutures, to maintain integrity of the sutured incision if the mattress tension sutures must be removed to avoid pressure necrosis caused by the accompanying stents. (d) Approximately 8 days after injury and 6 days after delayed primary closure, the cranial portion of the skin flap became necrotic (note the leathery appearance) due to insufficient blood supply. (e) The necrotic portion of the skin flap was excised, and the underlying wound bed, which was filled with healthy granulation tissue, was gently cleansed. The remaining wound healed by contraction and epithelialization, without complication, within 4 weeks.

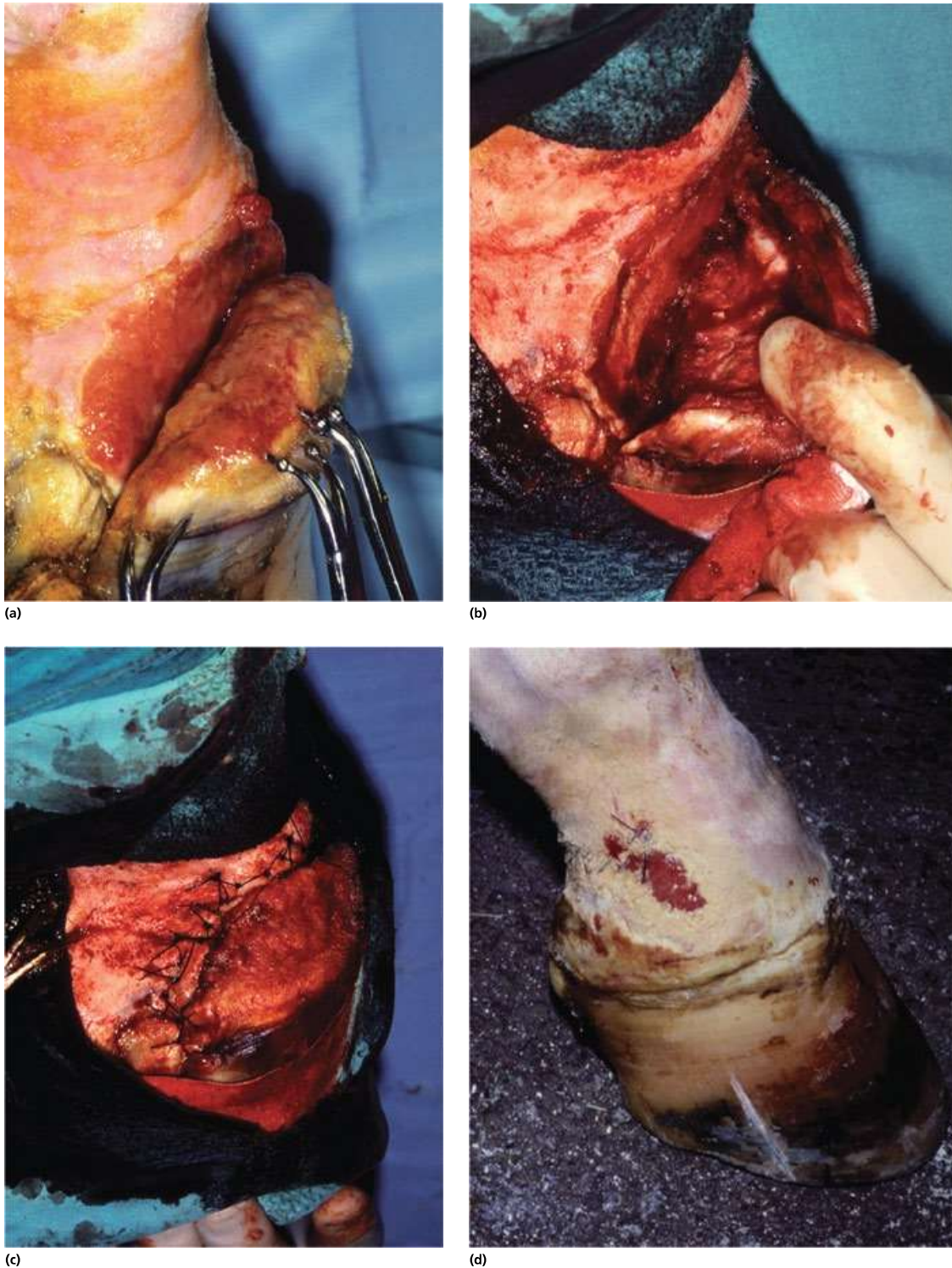


Figure 8.7 Same wound as in Figure 8.2. (a) The wound, 5 days later, after cleansing, debridement, and administration of antimicrobial therapy. Note the healthy bed of granulation tissue. This wound is ready for delayed secondary closure. (b) The wound, after excising granulation tissue. A portion of the lateral ungual cartilage was damaged and, therefore, excised (white tissue proximal to the gloved digit). (c) The partially sutured wound. The coronary band has been apposed at the heel bulb, but the skin at the dorsal limits of the wound (just to the right of the last suture) could not be apposed due to a tissue deficit (missing skin). A phalangeal cast was applied after surgery and left in place for 2 weeks. (d) The wound 2 weeks after cast removal. The sutured portion of the wound healed primarily, and the area of tissue deficit (granulating wound) healed by second intention beneath a bandage. The coronary band healed primarily, obviating the development of a defect in the hoof wall.

accumulation of fluid within the wound and subsequent separation of the tissue layers. A thick bandage or a cast is usually required to protect the repair when a wound closed by delayed secondary intention is located on the limb.

This approach to wound closure is relegated to wounds that are first seen by the veterinarian more than 1 week after injury or that are heavily contaminated or infected when first examined. The former situation arises quite frequently because many horse owners attempt to manage their horse's wound prior to consulting a veterinarian.^{36–38} In the latter situation, the initial management consists of cleansing and debriding the wound and then dressing and bandaging it appropriately until healthy granulation tissue fills the wound. Various types of dressings or negative pressure therapy may be used to encourage fibroplasia (the reader is referred to Chapter 6 for more information regarding wound dressings and to Chapter 22 for more information regarding negative-pressure therapy).³⁹

Delaying closure until after the appearance of healthy granulation tissue works well for contaminated or infected heel bulb lacerations; as is the case with primary closure of wounds in this area, the repair should be protected by a foot cast. The reader is referred to Chapter 7 for more information regarding techniques of bandaging and casting. Delayed secondary closure may be more challenging if the wound is located over a cannon bone, because mobilizing the surrounding skin sufficiently to suture the wound is difficult, even after the granulation tissue has been resected. Thus, primary closure, delayed primary closure, and second-intention healing are the only practical approaches to managing wounds in the metacarpal/metatarsal area. Free skin grafting of acute wounds or those that have developed a healthy bed of granulation tissue is also a useful technique to manage wounds in the metacarpal/metatarsal area and should be considered to avoid the long healing times associated with second-intention healing of degloving wounds in this area (see Chapter 18 for more information regarding skin grafting).

Second-intention healing

Healing of wounds is nearly always faster and more cosmetic when the wound is primarily closed. Moreover, experimentally created cutaneous wounds of horses healed by second intention have been shown to withstand a maximum breaking load equivalent to only 60% of the breaking force of normal, intact skin.⁴⁰ Additionally, skin appendages are usually absent in epithelial scars, resulting in the absence of pigmentation and hair as well as deficient functions, such as the production of sweat or sebum.

Unfortunately, many accidental wounds in horses are not amenable to primary closure because of massive loss of tissue or contamination. Moreover, wounds that are sutured often partially or completely dehiscence. Indeed, a retrospective study of more than 500 horses with accidental skin wounds showed that primary closure was successful in only 26% of the horses and

41% of the ponies in which it was attempted.⁹ Additionally, some owners are unwilling or unable to cover the immediate costs associated with primary closure of their horse's wound. Consequently, many wounds managed by equine practitioners must heal by second intention.

Second-intention healing relies on the body's ability to decrease the wound's surface area by contraction and to cover the remaining area with newly formed epithelium. Second-intention healing is selected to manage wounds characterized by extensive trauma to and/or loss of tissue and those that are heavily contaminated. Wounds caused by pressure or entrapment (e.g., a limb that has been trapped by a rope) are frequently treated by second-intention healing or by delayed secondary closure because the health of the traumatized tissue often continues to deteriorate after the injury was incurred, thereby threatening the integrity of any sutured closure. Burn injuries are another example of wounds best managed by second-intention healing and are discussed in Chapter 20.

Tip

- Allowing a wound to heal by second intention, while less expensive at the onset, usually incurs an expense similar to that incurred by primary closure because of the costs associated with labor (veterinarian's honorarium for farm visits to monitor healing or trim EGT) and with bandaging materials.

When second-intention healing is selected, the wound must still be cleansed and debrided to remove necrotic debris and reduce the bacterial burden. Good ventral drainage must be ensured to avoid accumulation of exudate and proliferation of bacteria within deep pockets underlying the skin. The wound is then dressed and bandaged, as required. The reader is referred to Chapters 5 and 6 for more information regarding dressings and the techniques of bandaging. The frequency of bandage change is dictated by the nature of the underlying wound and the selected dressing; additional cleansing and debridement may be required at bandage changes. If the wound is not bandaged, the skin ventral/distal to the wound should be kept clean, and petrolatum jelly applied to the skin to prevent scalding from serum and/or exudate draining from the wound. After healthy granulation tissue has filled the wound, the frequency and intensity of general wound care can be decreased, and at this stage of healing, many clinicians opt to leave the wound uncovered, particularly if it is located on a limb, to reduce the likelihood of having to trim EGT.

Wounds on the body left to heal by second intention often have acceptable cosmetic and functional outcomes, unless the wound was very large at the onset, necessitating healing, in large part, by epithelialization (Figure 8.8). Epithelial scars are thin and easily traumatized. Skin grafting may be useful to decrease epithelial scarring and should be considered in a wound healing by second intention as soon as the wound is covered by healthy granulation tissue (Figure 8.9); for more