ABSTRACT: Splint bone disorders in horses include exostoses and fractures in distal, middle, and proximal anatomic locations. The function of each splint bone depends on the size of the proximal articulation and the supporting soft tissue structures. Exostoses develop in response to inflammation but seldom cause lameness unless the inflammatory cause persists or suspensory ligament function is altered. Acute splint bone exostoses can be successfully treated with antiinflammatory drugs and rest, and chronic exostoses may require surgical treatment. Treatment options for splint bone fractures vary with the character and location of the fracture and include conservative management, surgical resection, and internal fixation. Surgical resection options for open splint bone fractures include segmental resection, which preserves the proximal and distal segments of the splint bone. The prognosis for splint bone disorders is generally good with timely diagnosis and treatment.

Disorders of the small metacarpal, metatarsal, or splint bones occur in horses of all ages. The distal and exposed locations of the splint bones render them prone to external trauma; however, injury also occurs with no history or evidence of external trauma, which correlates with biomechanical trauma from the forces of weight bearing and exercise. This article discusses exostoses and fractures, which are described as proximal, midshaft, and distal and are characterized according to severity and association with adjacent structures. Treatment options vary considerably with the location and severity of the lesion, but the prognosis is generally good for horses with appropriately managed splint bone injuries.

NORMAL ANATOMY

Consideration of anatomic relationships can be important in evaluating injury and formulating treatment plans, which vary according to the structural function of each splint bone. The splint bones, together with the cannon bone, form the skeletal structures of the metacarpus and metatarsus. The articular surfaces and proximal aspects of the splint bones provide structural support for the carpus and tarsus. Metacarpal splint bones have larger articular surfaces and more soft tissue attachments than metatarsal splint bones, indicating a greater weight support function in the forelimbs. The second metacarpal bone may articulate with the second carpal bone alone or with the second and third carpal bones.
bones combined.\textsuperscript{5,6} The fourth metacarpal bone articulates only with the fourth carpal bone. The second metatarsal bone articulates with the fused first and second tarsal bones, and the fourth metatarsal bone articulates with the fourth tarsal bone. The second metatarsal is typically smaller in diameter than the fourth metatarsal, but the articular surface of the fourth metatarsal is quite small in relation to the large proximal end.\textsuperscript{7}

The soft tissue attachments on the proximal aspects of the splint bones provide a tension force that supports the compressive forces exerted on the carpal and tarsal bones. The second metacarpal bone is attached proximally to the medial collateral carpal ligament, flexor carpi radialis, and extensor carpi obliquus. The fourth metacarpal bone is attached proximally to the lateral collateral ligament of the carpus, accessory carpo-metacarpal ligaments, and ulnaris lateralis tendon of insertion. Proximal metatarsal soft tissue support includes the medial collateral tarsal ligament and lateral tendon of the cranial tibial muscle, which attach to the proximal second metatarsal bone, as well as the long lateral collateral ligament and long plantar ligament originating on the plantar tuber calcis, which attach to the proximal fourth metatarsal bone.\textsuperscript{8,9}

The interosseous ligament attaches the proximal two-thirds of each splint bone to the cannon bone. Ligament fibers originate on the caudal surface of the third metacarpal/metatarsal and run in a caudoproximal direction to insert on the cranial surface of the splint bones.\textsuperscript{10} The interosseous ligament stabilizes the splint bones from tension and torsion forces exerted by proximal soft tissue attachments. As a horse ages, the interosseous ligament loses pliability and can mineralize. Les et al\textsuperscript{6} reported some degree of metacarpal fusion in 192 of 200 metacarpi in racing thoroughbreds and found that fusion of the second metacarpal to the third metacarpal is more common than fusion of the fourth metacarpal to the third metacarpal.

**EXOSTOSES**

An exostosis is defined as a benign new growth projecting from a bone surface.\textsuperscript{11} Exostoses of the second and fourth metacarpal/metatarsal bones have been referred to as splints, and in young horses, they are associated with the onset of training, conformation abnormalities (i.e., “bench knees”), improper hoof care, and nutrition imbalances.\textsuperscript{1,5,7} The inner cambial layer of the periosteum is active in young horses and tends to have an osteogenic response to inflammation. A contributing factor to periostitis and periosteal proliferation can be interosseous desmitis. Exostoses can also form secondary to blunt trauma, fracture, or sequestrum formation.

**Diagnosis**

Clinical signs associated with splint exostoses can be variable. Chronic exostoses are not usually painful; however, pain can be elicited on palpation, and lameness may be acutely present after trauma. Exostoses on the axial surface of the splint bone have been referred to as \textit{blind splints} and may not be readily detected; however, lameness may be present if new bone impinges on the suspensory ligament.\textsuperscript{8} Proximal exostoses (“knee splints”) may be painful and may predispose patients to carpal/tarsal arthritis.\textsuperscript{7} Mineralization of the interosseous ligament has been called “true splint” and is not typically a source of pain.\textsuperscript{1,8,12}

Diagnosis of splint exostoses depends on physical examination and lameness evaluation, including local anesthesia, and is confirmed with diagnostic imaging. Radiography can define lesion location and the presence of associated fracture, sequestra, or arthritis. Standard four-view studies and additional oblique projections may be necessary to completely identify the location and extent of the proliferative new bone (Figure 1).

![Figure 1—An oblique radiograph of the second and third metacarpals demonstrates bone production characteristic of a splint exostosis.](image-url)
Other imaging modalities can further define splint lesions and associated soft tissue injury. Scintigraphy may reveal inflammation in the soft tissues and bone.\textsuperscript{13} Computed tomography can delineate subtle anatomic lesions.\textsuperscript{14} Ultrasonography of the suspensory ligament can help determine the size of axial exostoses and the extent of associated suspensory desmitis.\textsuperscript{1,8,15}

**Treatment**

The goal of treating acute splint bone exostoses is reduction of inflammation and bone reactivity. Rest appears to be critical for success. NSAIDs, such as phenylbutazone (2.2 to 4.4 mg/kg PO sid or bid), can reduce inflammation, periosteal reaction, and pain. Topical dimethyl sulfoxide preparations, systemic 10% dimethyl sulfoxide (IV or PO), cold-water therapy or ice packing, and perilesional corticosteroid injections may also decrease local inflammation.\textsuperscript{1,7,16}

Counter-irritants (e.g., pin firing, freeze firing, sclerosing agents, internal and external blistering) have been and are still used to treat splint exostoses; however, the efficacy of these treatments has been questioned.\textsuperscript{1,7,16} Counter-irritants theoretically function to convert low-level inflammation to active, acute inflammation and promote more rapid osteogenesis; however, success has not been documented by controlled evaluation.\textsuperscript{10}

Surgical treatment for simple exostoses is not indicated acutely after injury. Remodeling of acutely injured bone may be a desired healing response; however, resection of proliferative bone may be indicated at a later date to improve cosmesis or remove axially oriented bone that interferes with suspensory ligament function.\textsuperscript{12,15}

**Prognosis**

The prognosis for return to athletic function after exostosis formation or removal is good. Concurrent suspensory desmitis or arthritis of the distal carpus/tarsus worsens the prognosis. Recurrence is the major complication after surgical excision of splint exostoses. Barber et al\textsuperscript{12} reported an excellent clinical appearance after surgical removal of splint bone exostoses; however, exostoses that develop in response to conformation abnormalities may have a reduced likelihood of acceptable cosmetic healing.

**DISTAL THIRD SPLINT BONE FRACTURES**

The most common fracture site in the splint bone is the distal third. Distal fractures are typically closed and can involve little or no evidence of external trauma. The average age of horses with distal fractures is reportedly 6 years.\textsuperscript{8,17} The left lateral and right medial metacarpal bones are the most common sites of distal splint bone fracture in thoroughbred horses.\textsuperscript{1,2} The most common sites of distal splint bone fracture in standardbred horses are the left medial and right lateral metatarsal bones.\textsuperscript{1–3} These fractures may result from increased axial compression in thoroughbred, or ligament and fascial tension in standardbred, racehorses racing in a counterclockwise direction.\textsuperscript{1–3} Fractures of the distal metacarpal and metatarsal bones were a consistent finding with in vitro fetlock hyperextension strain application during strength testing of the forelimb suspensory apparatus.\textsuperscript{4}

**Diagnosis**

Clinical signs of distal splint bone fractures include mild lameness, local swelling, and pain on palpation. Direct digital pressure on the skin over a fractured splint bone may cause increased lameness, and local anesthesia may help isolate the source of pain.\textsuperscript{18} Concurrent inflammation of the suspensory ligament and soft tissues of the fetlock joint is not uncommon.

Diagnosis of splint bone fractures (proximal, midshaft, or distal) usually depends on a complete physical examination and radiography. Nondisplaced fractures may not be radiographically visible until after bone resorption and remodeling begins, which may take 7 to 14 days. Additional diagnostic aids for acute fractures include infrared thermographic imaging and nuclear
scintigraphy. The soft tissue phase of nuclear scintigraphy may help evaluate suspensory ligament inflammation, and the bone phase may assist in diagnosing nondisplaced fractures. Ultrasonography of the suspensory ligament may be indicated with concurrent suspensory desmitis. Culture and sensitivity testing is indicated for all open fractures.

**Treatment**

Rest and administration of NSAIDs are the treatments of choice for closed distal splint bone fractures. Verschooten et al. reported an 80% incidence of spontaneous healing of distal splint bone fractures. Concurrent suspensory desmitis is often the cause of lameness; therefore, early decisions for resection of the distal splint bone may not be indicated. Surgical removal of the distal fragment is indicated with open displaced fractures or if the fracture is determined to be the cause of chronic lameness. Surgical resection should be performed with aseptic technique under general anesthesia. However, a simple distal splint ostectomy using sedation and local anesthesia can be performed with the horse standing.

**Prognosis**

The prognosis for soundness is good for horses with distal splint bone fractures. Suspensory desmitis affects the prognosis and is the most likely limiting factor for return to exercise. Periosteal proliferation at a fracture or resection site can affect cosmetic results but does not usually affect function.

**MIDDLE THIRD SPLINT BONE FRACTURES**

Midshaft fractures of the small metacarpal/metatarsal bones commonly result from external trauma.

**Diagnosis**

Clinical signs include mild to moderate lameness and local signs of inflammation. An open wound and/or draining tract is often present and may indicate sequestrum formation.

**Treatment**

Closed, nondisplaced midshaft fractures heal well with stall rest and NSAID administration. Open midshaft fractures usually require surgical treatment. Resection of the portion of a splint bone distal to an open midshaft fracture site has historically been recommended. However, segmental resection of the traumatized midshaft has been successful, leaving the distal segment of the splint bone undisturbed (Figures 2A and 2B).

**Prognosis**

The prognosis for horses with midshaft splint bone fractures is good. Segmental resection may be less invasive and may reduce morbidity associated with a more extensive incision and resection of longer portions of the fractured splint bone.

**PROXIMAL THIRD SPLINT BONE FRACTURES**

Proximal splint bone fractures often result from external trauma and are frequently open.
Diagnosis

Clinical signs can vary due to the association of the carpal and tarsal joints and the proximal soft tissue attachments. Lameness can be mild to severe depending on fracture severity, articular stability, and articular sepsis. Instability of the fracture and the articular surface can result from soft tissue distraction forces, which may displace proximally the distal end of the proximal fragment. Proximal metacarpal splint fractures may have concurrent effusion of the distal carpal joints because of communication between the intercarpal and carpometacarpal joints. In contrast, proximal metatarsal splint fractures seldom cause palpable effusion in the distal tarsal joints, even in the presence of sepsis.

Diagnostic evaluation of proximal splint fractures should include examinations of the distal carpal or tarsal joints. A complete radiographic examination should include the carpus/tarsus. Potentially contaminated joints near an open wound should be distended with a sterile solution from a site distant to the wound to determine articular communication. Contrast radiography may also be used to determine articular communication with an open wound. Early determination of joint involvement is essential for timely, appropriate treatment.

Proximal Metacarpal Fractures

Treatment

Successful management of open articular fractures of the proximal metacarpal splint bones depends on early diagnosis and treatment. The distal carpal joints should be treated with intra-articular lavage and antibiotics when contaminated. Infected bone and soft tissue should be debrided and appropriate antibiotic therapy initiated after tissue sampling for culture and sensitivity testing. Unstable articular fractures may require internal fixation. Delayed fracture repair and wound closure may be necessary to decrease bacterial numbers in severely contaminated wounds. Intensive local wound treatment may be necessary for 3 to 7 days before a fracture is repaired. Nonarticular proximal metacarpal splint bone fractures may require internal fixation and debridement if the fracture is open. Unstable fractures of the proximal portion of the second metacarpal bone, whether open or closed, usually require repair to provide stability for the large articular surface. However, fractures with intact supportive soft tissues may not have substantial fragment displacement, and repair with implants may not be required.

Open fractures with septic osteomyelitis or large sequestra require resection of infected bone. Removal of more than 50% of the medial metacarpal bone can result in carpal instability, and the remaining proximal splint bone may need to be fixed in position. However, large segments of splint bones have been resected without a resultant need for stabilization with orthopedic implants.

Prognosis

The prognosis for open or closed proximal metacarpal splint bone fractures is good with early reduction, fixation, and rest. The prognosis is guarded when chronic infectious arthritis or osteomyelitis is present.

Proximal Metatarsal Fractures

Treatment

Open and/or comminuted fractures of the fourth metatarsal can successfully heal with stall confinement and wound management (Figure 3). Treatment should be initiated within 48 hours of trauma for the best outcome. Extensive debridement, including amputation of the entire distal portion of the splint bone, may be
needed. Removal of the entire body of the fourth metatarsal has been successfully performed. Complete removal of the fourth metatarsal may be indicated for severe comminution, crushed bone with existing infection, or fractures that do not respond to conservative management. This has resulted in five of seven horses returning to athletic function.

Internal fixation is recommended for severely displaced or articular metatarsal splint bone fractures. However, closed and minimally displaced proximal fourth metatarsal fractures can heal with stall confinement alone.

**Prognosis**

The prognosis for proximal second and fourth metatarsal fractures is good. Fractures of the fourth metatarsal are reported to have a good prognosis, even with chronic infection.

### REFERENCES


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**ARTICLE #6 CE TEST**

1. **Chronic exostoses**
   - a. are usually painful.
   - b. are not usually painful but may cause lameness if suspensory ligament function is altered.
   - c. require surgical management.
   - d. are diagnosed with ultrasonography.

2. **Acute exostoses**
   - a. require surgical management.
   - b. can be managed with antiinflammatory drugs.
   - c. do not cause lameness.
   - d. resolve with the onset of training.
3. Distal splint bone fractures
   a. typically show no evidence of external trauma.
   b. typically show evidence of external trauma.
   c. do not cause lameness.
   d. are not associated with suspensory ligament function.

4. Proximal splint bone fractures
   a. do not affect weight-bearing structures.
   b. may result in articular instability or sepsis.
   c. are frequently closed fractures.
   d. cause palpable effusion in the distal tarsal joints.

5. Midshaft splint bone fractures
   a. are often associated with a draining tract.
   b. cause severe lameness.
   c. do not result from external trauma.
   d. are not associated with open wounds.

6. Splint bone fractures
   a. are definitively diagnosed with a physical examination.
   b. are definitively diagnosed with local anesthesia.
   c. are always radiographically apparent.
   d. may require 7 to 14 days for bone resorption and remodeling to be radiographically visible.

7. Distal splint bone fractures
   a. require surgical ostectomy.
   b. reportedly have an 80% incidence of spontaneous healing.
   c. do not usually heal with conservative management (i.e., rest and NSAIDs).
   d. are not associated with suspensory desmitis.

8. Midshaft splint bone fractures
   a. can be surgically managed with segmental resection.
   b. usually heal with rest and NSAIDs.
   c. require complete distal splint bone ostectomy.
   d. are not associated with sequestered bone.

9. Proximal metacarpal splint bone fractures are often open and
   a. may need intensive wound treatment for several days before fracture repair.
   b. do not need to be debrided.
   c. do not need to be stabilized.
   d. should optimally be stabilized with lag screws in the cannon bone.

10. Proximal metatarsal fractures
    a. do not heal with stall confinement and wound management.
    b. do not require internal fixation.
    c. often require extensive debridement.
    d. have a poor prognosis.