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Metacarpal and Metatarsal Fractures in Dogs

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Abstract: *Metacarpal and metatarsal fractures are common causes of lameness in dogs and are often due to high-energy trauma. Potentially life-threatening injuries may occur concurrently and must be managed immediately, before injuries to the metacarpals or metatarsals are addressed. The diagnosis is based on the history, physical examination findings, and radiographs. Conservative and surgical therapies exist; however, definitive recommendations regarding the optimum treatment modality have not been established.*

Metacarpal and metatarsal fractures are common in small animal practice, accounting for 8.1% to 11% of all fractures in dogs.[1,2] Most are transverse fractures, and many involve three or more metacarpal and/or metatarsal bones.[3] Although recommendations regarding the optimum treatment and management of metacarpal and metatarsal fractures have been reported, there is little significant evidence-based medicine to support them. This article presents the pertinent anatomy, history, and diagnosis of metacarpal and metatarsal fractures in dogs. Conservative and surgical treatment options, including postoperative management and complications, are also reviewed.

Common Anatomy of the Metacarpus and Metatarsus

The metacarpal bones are numbered 1 to 5 from medial to lateral[4,5]; metatarsal bones are numbered 2 through 5 (**FIGURE 1**). A first metatarsal may rarely be present. Each bone consists of a proximal base, a body, and distal head.[4,5] Metacarpals and metatarsals 2 through 5 articulate with the carpal or tarsal bones proximally and their corresponding phalanges distally.[4,5] The metacarpophalangeal and metatarsophalangeal joints are supported by medial and lateral collateral ligaments and a synovial joint capsule.[4,5] These joints possess two palmar or plantar sesamoid bones and a single dorsal sesamoid. Further support is provided by the intersesamoidean ligaments, tendons of insertions of the interosseous muscles, and lateral, medial, distal, and cruciate sesamoidean ligaments.[6,7] Metacarpals and metatarsals 3 and 4 are considered the major weight-bearing bones.

[a]Dr. Roush discloses that he has received financial support from Hill's Pet Nutrition, Inc.

History

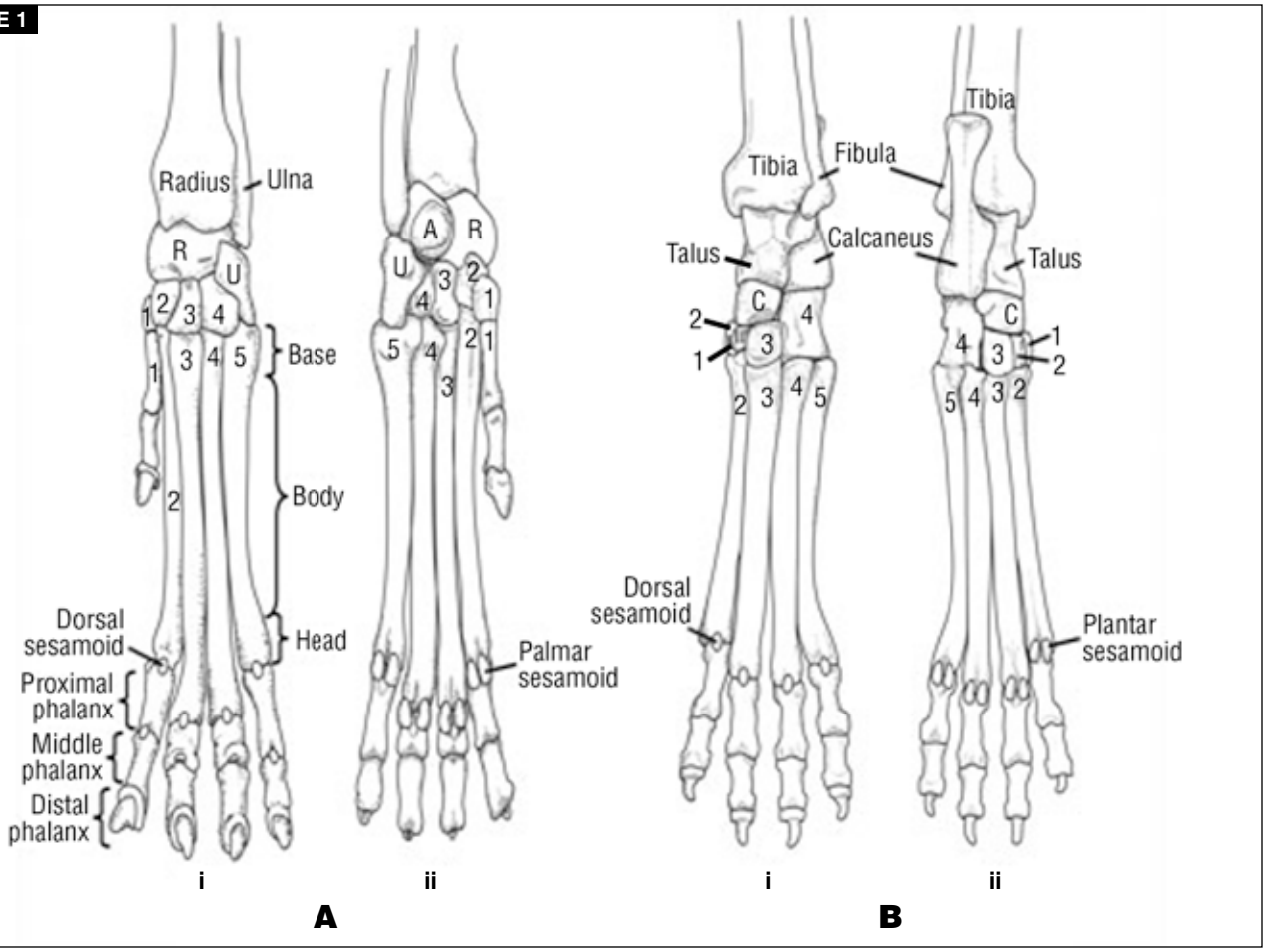
Trauma accounts for most metacarpal and metatarsal fractures in companion dogs.[1,2] Racing greyhounds are prone to developing stress fractures of the metacarpals and metatarsals. Young or unfit dogs that start racing prematurely tend to be predisposed. In this breed, metacarpal 5 of the left forelimb is the most commonly affected, with metacarpal 2 of the right forelimb and metatarsal 3 of the right hindlimb also predisposed.[8–11] It is hypothesized that these stress fractures are due to the excessive loads borne by these bones while negotiating the bends in the counterclockwise greyhound tracks.[8]

Fractures of the metacarpal bones after pancarpal arthrodesis have also been reported.[12] In one study, fractures associated with pancarpal arthrodesis occurred in six of 54 dogs.[12] All six dogs had fractures through the shaft of the third metacarpal; two dogs also had a fracture of metacarpal 4. The authors concluded that fewer fractures occurred when more than 53% of the bone length was covered by the dynamic compression plate.

Diagnosis

The diagnosis is typically based on the history, orthopedic examination, and radiography. Because trauma is the most common etiology, concurrent injuries are frequently seen. In one study, six of eight dogs with metacarpal/metatarsal fractures due to motor vehicle trauma had additional fractures or orthopedic injury.[3] Potentially life-threatening conditions often accompany major trauma and must be managed before injuries to the metacarpals or metatarsals are considered.

FIGURE 1



Images courtesy of Mal Hoover, Kansas State University

Anatomy of the forepaw and hindpaw. (A) Dorsal (i) and palmar (ii) aspects of the forepaw. (B) Dorsal (i) and plantar (ii) aspects of the hindpaw. *A* = accessory carpal bone, *C* = central tarsal bone, *R* = radial carpal bone, *U* = ulnar carpal bone.

Most animals that present with an acute injury are non–weight bearing on the affected limb. However, animals with chronic injuries may present with more subtle lameness. Soft tissue swelling, pain, and crepitus over the fracture site are common.[7] Fractures may be open and associated with extensive soft tissue injury.[13]

Because the bases of the second and fifth metacarpals are points of ligamentous attachment, fractures of these areas lead to varying degrees of valgus or varus displacement of the foot, respectively.[14] In addition, fractures of the condyle of the metacarpal or metatarsal head result in luxation or subluxation of the associated phalangeal joint and deviation of the affected digit.[7]

Radiographic evaluation of the metacarpus or metatarsus is best performed with the patient sedated, using fine-detail film and high-detail screens.[13] Lateral and dorsopalmar projections should be assessed for the location and type of fracture, degree of displacement, and articular involvement and can assist in determining if an open or closed fracture is present[7] (**FIGURE 2**). Stress views of the carpus and tarsus can be obtained if ligamentous injuries are suspected.[13]

Treatment

Indications for conservative versus surgical treatment of metacarpal and metatarsal fractures in dogs have not been fully supported. The current guidelines[3,14–16] recommend conservative treatment using external coaptation when (1) the fractures are minimally displaced, (2) only one or two metacarpal and/or metatarsal bones are involved, and (3) at least one of the major weight-bearing bones (3 or 4) is intact.

Surgical intervention has been recommended when the fragments are markedly (>50%) displaced or comminution exists; more than two bones are involved; both metacarpals or metatarsals 3 and 4 are fractured; the fractures involve the middle or distal metacarpal/metatarsal region (due to greater incidence of fracture displacement); the articular surfaces are involved; the fracture is open; the base of the second or fifth metacarpal or metatarsal is fractured; or the patient is a large-breed, working, athletic, or show dog.[3,7,14,16,17]

The veterinary literature has produced conflicting reports regarding the aforementioned guidelines. One very early study[16] reported unsuccessful outcomes in 54% and 85% of dogs with distal extremity fractures treated with conserva-

FIGURE 2

Images courtesy of Dr. Richard Jerram, Veterinary Specialist Group, New Zealand

Radiographs illustrating transverse, caudally displaced shaft fractures of metacarpals 3, 4, and 5 in a dog. (A) Left lateral view. (B) Dorsopalmar view.

FIGURE 3

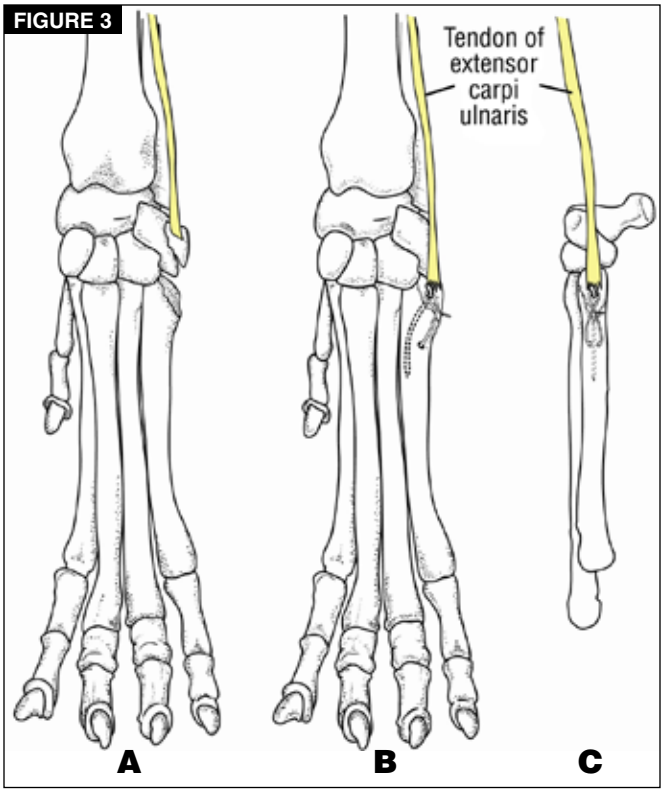


Illustration of the use of the tension band technique for surgical fixation of a metacarpal fracture. (A) Fracture of the base of the fifth metacarpal bone. (B) Dorsal view. (C) Lateral view.

Reproduced with permission from Piermattei DL, Flo GL, DeCamp CE, eds. *Brinker, Piermattei, and Flo's Handbook of Small Animal Orthopedics and Fracture Repair.* 4th ed. St Louis: Elsevier; 2006:413.

tive management and internal fixation, respectively. This study reported that the degree of fracture displacement and articular surface involvement was a significant predictor of posttreatment complications. The number of bones fractured and whether the fracture was open or closed did not significantly affect complication rates.

Kapatkin and colleagues[17] showed that the amount of fracture displacement, fracture configuration, and number of metacarpals and/or metatarsals fractured in the same limb did not have a statistically significant effect on outcome. In contrast to the study by Manley,[16] 44% of dogs treated conservatively and 23% of dogs treated with surgical intervention had unsuccessful outcomes in this study.

Recommendations for when to choose internal fixation for metatarsal fractures in people are very similar to those in the veterinary literature.[17] It has been suggested that the veterinary guidelines have been extrapolated from the human literature and may not be accurate in dogs.[17] Prospective, randomized, controlled studies comparing surgical and conservative options for metacarpal and/or metatarsal fractures in dogs are required before definitive recommendations can be made.

Fractures of the Base

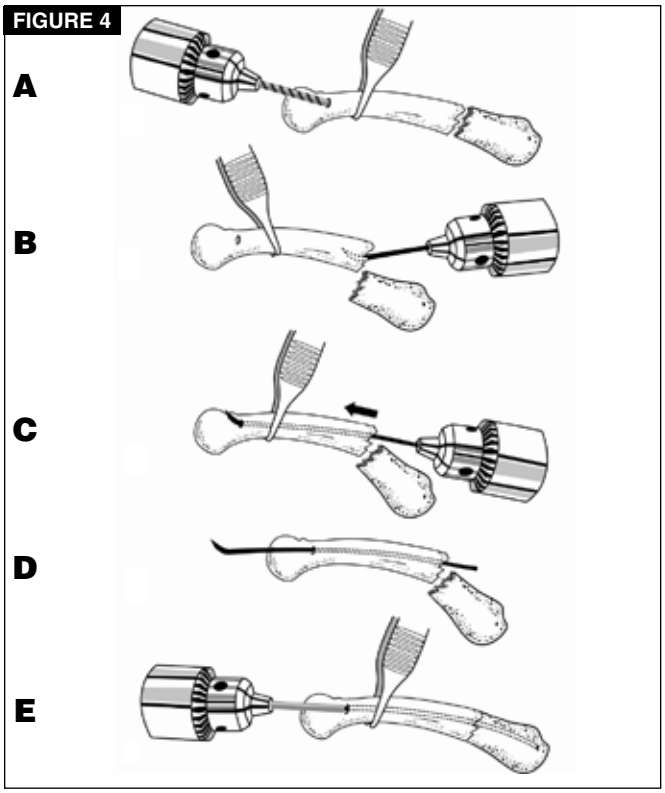
Basilar fractures most commonly affect the second and fifth metacarpal and metatarsal bones. Because the basilar segment of these bones is a point of ligamentous insertion, fracture of the second metacarpal/metatarsal can result in valgus displacement of the paw, whereas fracture of the fifth metacarpal/metatarsal can produce varus displacement.[13,14] Nondisplaced fractures may be treated with external coaptation for 6 weeks using a Mason metasplint or a molded fiberglass splint or cast. However, in our opinion, these fractures heal poorly with conservative treatment because of ligamentous tension on the fragment, and subsequent valgus or varus nonunions are a major complication.[13,14,18,19]

Open reduction and internal fixation of displaced basilar fractures may be accomplished with a tension band wire technique (**FIGURE 3**) or lag screw. Comminuted fractures, especially in larger dogs, may be treated using small cuttable plates or lag screws in combination with cerclage wire.[14] Additional support should be provided via a cast or splint for 6 weeks, during which the animal should be cage confined.[7,14]

Fractures of the Shaft

The use of a Mason metasplint or cast is typically reserved for minimally displaced fractures affecting one or two metacarpals or metatarsals (excluding involvement of both 3 and

FIGURE 4



Intramedullary pinning of metacarpal and metatarsal fractures. (A) A hole is drilled in the dorsal aspect of the distal end of the fractured bone. (B) The pin tip is bent 35° dorsally and is advanced from the fracture site toward the predrilled hole. (C) The bent pin tip is passed through the dorsal drill hole. (D) The pin is pulled farther through the drill hole. (E) The pin is driven into the proximal fracture segment after fracture reduction.

Reproduced with permission from Benedetti LT, Berry K, Bloomberg M. A technique for intramedullary pinning of metatarsals and metacarpals in cats and dogs. *JAAHA* 1986;22:149-152.

4).[3,14–16] The splint or cast and cage confinement should be maintained for 6 weeks, at which time repeat radiographs should be taken to assess healing.[13]

Techniques for surgical fixation include the use of intramedullary pins, cerclage wire, lag screws, small bone plates, and external skeletal fixation.[3,7,10,13,14,17,20]

Small-diameter pins (1.2 to 1.5 mm) are necessary because the thick cortices and small intramedullary canals make pin placement difficult.[7,14] It is important to avoid iatrogenic damage to the articular cartilage or interference with the motion of the metacarpophalangeal joint.[7,13,14] Benedetti and colleagues[21] described a technique for intramedullary pinning of metacarpal/metatarsal fractures (**FIGURE 4**) that involves drilling a hole one size larger than the intramedullary pin, aimed proximally at a 45° angle. The tip of the intramedullary pin is then bent, inserted at the fracture site, and advanced until it exits the drill hole. The pin is pulled out slightly, the fracture reduced, and the pin driven into the base of the proximal fracture segment. The distal end of the pin is bent proximally and the pin cut short.[21]

FIGURE 5

Image courtesy of Dr. Richard Jerram, Veterinary Specialist Group, New Zealand

Veterinary cuttable bone plates are used for fixation of metacarpal fractures in a young dog.

Lag screw fixation with 1.5- to 2.0-mm screws is a valuable method of surgical repair, especially in long oblique and spiral fractures.[14]

Small bone plates are valuable in large or athletic dogs and when the fracture is comminuted or particularly unstable.[13,14] Veterinary cuttable plates can be cut to the desired length, are easily contoured, have a large number of screw holes, and are relatively low priced, making them ideal for metacarpal or metatarsal shaft fractures (**FIGURE 5**). Their low profile also helps overcome the problem of inadequate soft tissue coverage during closure of the incision.

De La Puerta and colleagues[20] reported the outcome of an epoxy putty external skeletal fixation system for fractures of the four main metacarpal and metatarsal fractures in 11 dogs and 11 cats (**FIGURE 6**). The mean time to frame removal was 8.5 weeks, and all patients were deemed to have normal function at long-term follow-up (mean: 33 months). One of the major advantages of the epoxy fixator system is that the connecting bar can accommodate multiple pins in varying planes. This is significant because of the anatomic configuration of the metacarpal and metatarsal bones. Proximally, the bases of the metacarpals and metatarsals are aligned together in the frontal plane, allowing a single pin to engage all four bones (**FIGURE 7**). As the bones diverge distally, they form a configuration that is convex in cross-section, necessitating the use of multiple pins in different planes to obtain maximum bone purchase (**FIGURE 7**). De La Puerta et al concluded that although anatomic alignment of the fracture gap is ideal for bone healing, a good outcome can still be achieved even if healing results in malunion and/or synostosis.

Risselada and colleagues[22] described the use of an external skeletal traction device for distal metacarpal/metatarsal fractures in 11 dogs for a mean of 45 days. The apparatus, which was adapted from human medicine, applied traction to the digits to obtain and maintain alignment of the fracture ends. Nine of 11 dogs had full union at the time of fixator removal, and eight of the 11 dogs were deemed to have a good functional outcome at final follow-up. The

FIGURE 6

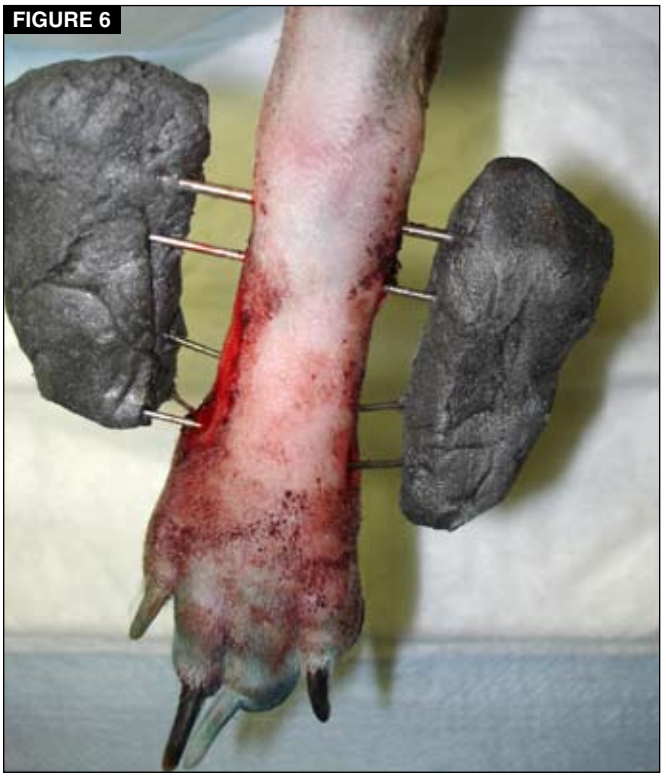
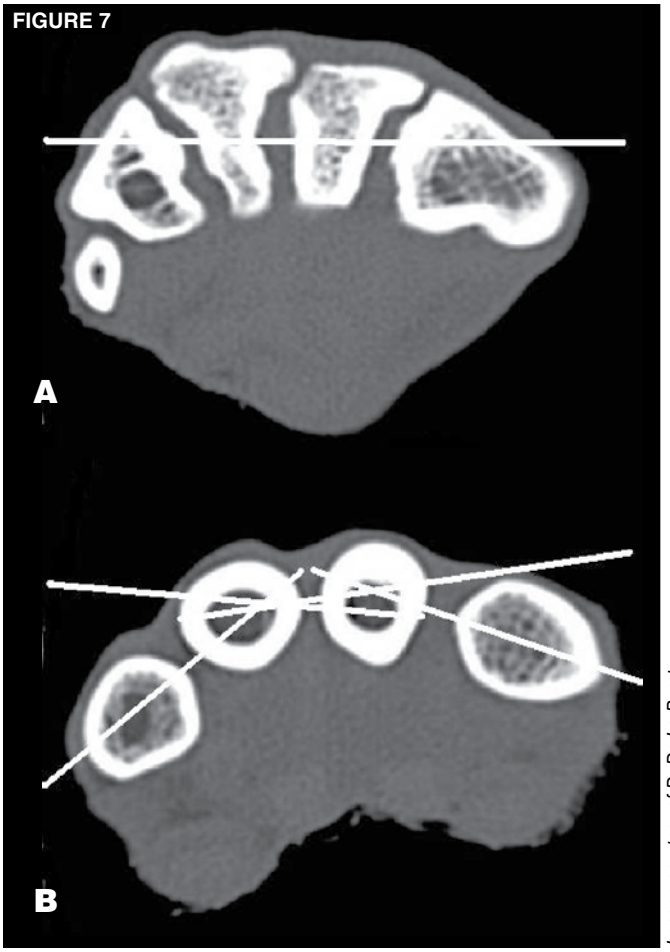


Image courtesy of Dr. Benito De La Puerta, North Downs Specialist Referrals, United Kingdom

Postoperative image illustrating the use of an epoxy external skeletal fixation system for the fixation of metacarpal shaft fractures in a dog.

FIGURE 7



Images courtesy of Dr. De La Puerta

Computed tomography (CT) images of metacarpal configuration in a dog. (A) Transverse CT image illustrating the configuration of the bases of all five metacarpals. This configuration allows for a single pin (*white line*) to engage metacarpals 2, 3, 4, and 5 in a single plane. (B) Transverse CT image illustrating the configuration of the heads of metacarpals 2, 3, 4 and 5. Note that because of the convex configuration distally, multiple pins (*white lines*) in varying planes must be used to engage all four bones.

authors concluded that in multiple metacarpal/metatarsal fractures and open fractures requiring frequent wound care, the external skeletal traction device can provide a valuable alternative to open reduction and internal fixation.[22]

Fractures of the Head

Fractures of the head of the metacarpal or metatarsal bones are rare.[7] Because the collateral ligaments originate on the condyle of the metacarpal/metatarsal bone, these fractures typically result in instability and luxation of the metacarpophalangeal or metatarsophalangeal joint[14] (**FIGURE 8**). External coaptation does not usually provide adequate intraarticular alignment of the fracture segments, leading to degenerative joint disease.[14] Internal fixation with either lag screws or hemicerclage wire offers the best chance for return to normal function[14] (**FIGURE 8**). The internal fixation should be supplemented with an external cast or splint and the animal cage confined for 6 weeks.[7,14] If chronic lameness results secondary to degenerative joint disease, amputation at the affected metacarpophalangeal or metatarsophalangeal joint provides pain relief, especially if only the second or fifth digit is involved.[7,14]

Stress Fractures

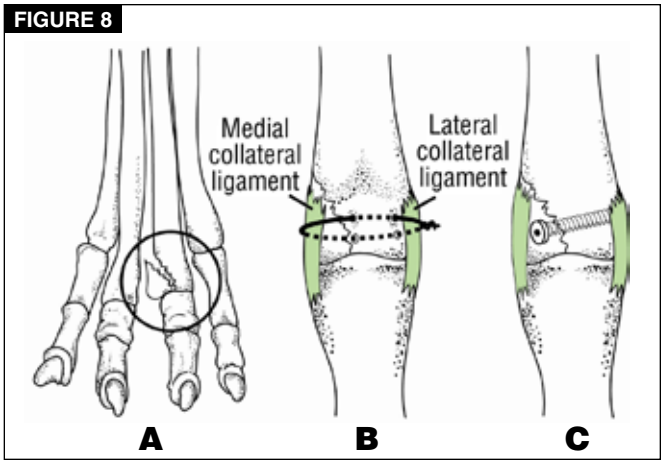
Stress fractures in greyhounds may be classified into three categories:

Type 1: Mild weight-bearing lameness begins after a race or on the following day. Radiographically, the diaphysis has cortical thickening and increased radiodensity of the medullary canal.[9] Strict rest for 4 weeks followed by a restricted exercise program allows the bone to gradually regain strength.[7,9]

Type 2: Moderate weight-bearing lameness begins immediately after a race, and a nondisplaced diaphyseal hairline fracture may be visible on radiographs.[9] External coaptation using a molded splint or cast for 4 weeks is recommended.[14] A gradual return to exercise may be instituted after the splint or cast is removed.

Type 3: A complete fracture with palmar or plantar displacement of the fragment, often comminuted, is visible on radiographs. External coaptation or internal fixation using lag screws or cuttable plates may be used. Reports of treat-

FIGURE 8



Illustrations of the use of cerclage wire and lag screw fixation. (A) Fracture of the medial condyle of the head of the fourth metacarpal bone. (B) Wire technique. To avoid drilling a hole through the small fragment, two holes are drilled in the metacarpal bone, and the wire is passed through the holes and around the fragment. If the wire can be passed through the ligamentous tissue, it will have less tendency to slip off the fragment. (C) Lag screw fixation with 1.5- or 2.0-mm screws is ideal if the fragment is large enough.

Reproduced with permission from Piermattei DL, Flo GL, DeCamp CE, eds. *Brinker, Piermattei, and Flo's Handbook of Small Animal Orthopedics and Fracture Repair.* 4th ed. St Louis: Elsevier; 2006:419.

Key Facts

- Patients with metacarpal or metatarsal fractures may have concurrent, potentially life-threatening injuries that must be managed immediately, before injuries to the metacarpals/metatarsals are addressed.
- Solid indications for conservative versus surgical treatment of metacarpal and metatarsal fractures in dogs have not been established.
- In contrast to companion animals, a successful outcome for greyhounds or other athletes treated for metacarpal/metatarsal fractures is defined as the ability of the dog to return to competition without impedance in form.
- All metacarpal/metatarsal fractures should be coapted in a cast or splint and the animal cage confined, regardless of the type of internal fixation used.
- Most metacarpal or metatarsal nonunions cause residual lameness, and a subsequent surgery may be indicated.

ment results are limited, but the prognosis for return to adequate function is typically poor. In one study, 16 of 22 dogs treated for type 3 stress fractures recovered sufficiently to be trialed. Six of the 16 were retired due to poor performance, two suffered further fractures, and four raced in fewer than 10 races each.[10]

The level of healing required for normal function in racing and other working dogs is greater than that in companion animals. Treatment success in racing dogs is defined as the ability of the dog to return to racing without impedance in form.

Postoperative Management and Complications

All animals should be cage confined and the fractures coapted in a molded splint or cast for 6 weeks, in addition to any internal fixation used. The splint or cast should be changed weekly. The owner should be taught to check the cast or splint daily for signs of limb swelling, dermatitis, pressure sores, and other complications associated with external coaptation.[19] Radiographs should be taken to assess the degree of fracture union when the cast or splint is removed.[14] After cast or splint removal, activity should be restricted for a further 4 weeks, at which time a gradual return to exercise may be implemented.[7,14]

The general guidelines recommend removing all intramedullary pins (especially those inserted from the distal joint area) as soon as callus formation is well established.[3,7,14,16] Bone plates are usually removed 3 to 4 months after surgery, while screws and cerclage wire may be left in place.[7,14] Currently, there are no data to support these recommendations.

The need for implant removal after visible fracture healing is controversial. The disadvantages of removing orthopedic implants include potential damage to the local blood supply, increased total recovery time and expense, and potential refracture of the injury site.[10,17] However, implant removal can help prevent chronic discomfort associated with implant irritation. We recommend leaving implants in place unless clinical evidence of discomfort exists.

Complications of metacarpal or metatarsal fracture repair include malunion, nonunion, implant loosening and migration, osteomyelitis, degenerative joint disease, and residual lameness.[3,16] Because all animals are placed in a molded splint or cast, complications associated with external coaptation should also be considered.[19] Most metacarpal/metatarsal nonunions cause residual lameness, and a subsequent surgery is often required.[16]

Conclusion

Metacarpal and metatarsal fractures are common in dogs and are most often due to external trauma. The diagnosis can usually be made based on a thorough orthopedic examination and radiography of the affected area. Studies evaluating long-term outcomes of conservative and surgical therapy in the treatment of metacarpal and metatarsal fractures are lacking. General indications for surgery include fractures of

both the third and fourth metacarpal or metatarsal bones and basilar, articular, distal diaphyseal, and open fractures of any of the metacarpals or metatarsals. Prospective, randomized, controlled studies comparing treatment options for metacarpal/metatarsal fractures are required before recommendations regarding the optimum treatment modality can be made.

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1. **Which statement regarding the anatomy of the metacarpus is correct?**
   - **a.** The metacarpal bones are numbered 1 to 5 from medial to lateral.
   - **b.** The metacarpophalangeal joints possess two palmar sesamoid bones and a single dorsal sesamoid.
   - **c.** Metacarpals 3 and 4 are the major weight-bearing bones.
   - **d.** all of the above

2. **Which statement regarding metacarpal/metatarsal fractures is true?**
   - **a.** Concurrent injuries are common.
   - **b.** Racing greyhounds are predisposed to stress fractures of the right fifth metacarpal.
   - **c.** Varus displacement of the foot is evident with fractures of the base of the second metacarpal or metatarsal bones.
   - **d.** all of the above

3. **When is conservative treatment for metacarpal or metatarsal fractures not recommended in the current guidelines?**
   - **a.** Only one or two metacarpals/metatarsals are involved.
   - **b.** The fracture is minimally displaced.
   - **c.** An articular surface is involved.
   - **d.** At least one of the major weight-bearing bones is intact.

4. **Surgical intervention for metacarpal/metatarsal fractures is recommended when**
   - **a.** the fracture is comminuted.
   - **b.** both metacarpals or metatarsals 3 and 4 are involved.
   - **c.** the base of the second or fifth metacarpal is fractured.
   - **d.** all of the above.

5. **Which statement regarding basilar fractures of the metacarpals/metatarsals is false?**
   - **a.** The second and fifth metacarpal/metatarsal bones are most commonly affected.
   - **b.** Basilar fractures of the fifth metacarpal/metatarsal can result in valgus deformity of the foot.
   - **c.** Internal fixation of basilar fractures may be accomplished with a tension band technique or lag screw fixation.
   - **d.** Internal fixation should be supported by a splint or cast for 6 weeks.

6. **Techniques for surgical fixation of metacarpal/metatarsal shaft fractures include the use of**
   - **a.** intramedullary pins.
   - **b.** lag screws.
   - **c.** bone plates.
   - **d.** all of the above

7. **Which statement regarding metacarpal/metatarsal stress fractures in dogs is false?**
   - **a.** They occur most commonly in racing greyhounds.
   - **b.** Type 1 stress fractures are associated with increased cortical thickening.
   - **c.** The prognosis for return to racing function is excellent for type 3 stress fractures if internal fixation is used.
   - **d.** Young or unfit dogs that start racing prematurely are predisposed.

8. **All animals should be cage confined and metacarpal/metatarsal fractures coapted in a molded splint or cast for**
   - **a.** 10 days.
   - **b.** 2 to 3 weeks.
   - **c.** 6 weeks.
   - **d.** 8 to 10 weeks.

9. **Disadvantages of implant removal after fracture healing include**
   - **a.** potential disruption to the local blood supply.
   - **b.** potential refracture.
   - **c.** increased recovery time and expense.
   - **d.** all of the above

10. **Complications of metacarpal/metatarsal fracture repair include**
    - **a.** osteomyelitis.
    - **b.** nonunion.
    - **c.** degenerative joint disease.
    - **d.** all of the above