# 20 Foot Disorders

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## INTRODUCTION

The prevalence of foot problems in elephants is unknown because no centralized reporting system has been established. In a retrospective study of 379 elephants, 50% were affected by foot disorders.[34] Few institutions have been spared the grief and frustration of dealing with elephant foot problems. It is the author's opinion that nonresolvable foot infection and arthritis are major causes necessitating euthanasia in elephants. It is unlikely that an elephant will progress through life without requiring periodic pedicures to keep the feet healthy. African elephants seem to have fewer foot problems than Asian elephants, but the reason for the difference is unknown.

A glossary of terms describing the elephant foot and foot conditions as seen by caretakers and veterinarians is found in Appendix 6.

Elephants' foot health would be enhanced if they lived in a natural habitat, which is defined as a large space with diverse topography and natural substrate. There should be wetlands, seeded and native pastures, wooded areas, natural year-round water (ponds, washes, streams, and dry creek beds), all with sufficient vegetation to maintain the elephants.[6] In a natural habitat, elephants spend their day walking, eating, bathing, and digging in soil. Natural vegetation, particularly browse, contains necessary trace minerals and vitamins that promote foot health. Elephants use their feet to help them forage. For instance, by placing a foot on a clump of grass, they pull grass blades between their toes which helps groom the interdigital skin and cuticles.[6]

It is not possible to provide the foregoing for captive elephants, except in rare situations. However, if elephant managers understand and appreciate the benefits of natural habitat to foot health, they might be better able to approximate natural habitat.

Facility design has an influence on foot health. Adequate drainage of floor surfaces in an elephant barn is critical. Architects often don't consider the amount of water necessary for cleaning and bathing or the volume of urine produced daily by elephants (54.4 L (5 gal)/4000 kg elephant). Drains are frequently installed that cannot cope with the volume of liquid or fail to capture debris before it enters the sewage system, causing obstructed sewage lines. See Chapter 5 for more detail.

Outdoor enclosure substrates are also important. Elephants should be allowed to dig. Clay soil, decomposed granite, or crushed limestone should be avoided because these tend to pack into pockets and crevices in the sole and behind the toenail. The best substrate is river-washed sand because it dries quickly in wet conditions.

## FOOT

The elephant foot is highly specialized to accommodate the heavy weight of the animal. The anatomy of the feet of Asian and African elephants is basically the same, with slight differences in shape and the number of toenails.[13,31,33,57,58] Basically there are five digits, which are not all identifiable externally, but some digits are represented by variable numbers of phalanges and toenails. Asian elephants usually have five toenails on each front foot (Fig. 20.1) and four on the rear foot (Fig. 20.2). African elephants generally have only four toenails on the front foot (Fig. 20.3) and three on the rear (Fig. 20.4). In general, only digits two, three, and four have three phalanges each (Fig. 20.5). Digit one may have only a metacarpal or also only one phalanx, and digit five has two phalanges. The distal phalanx (P3) may not articulate with P2. It is attached to a toenail by multiple laminae (Fig. 20.6).

The foot has an integumentary covering consisting of skin, toenails, and a cornified but flexible sole (slipper) similar to the bulb of the heel in a bovine (Fig. 20.7). See also Figures 20.1 to 20.4.

The bones of the feet have been well described by Smuts.[57,58] Elephant limb bones are massive and lack a

***Figure 20.1.*** *Right forefoot of an Asian elephant. Top: slipper; Bottom: lateral view.*

marrow cavity.[43,55] The marrow cavity is replaced with a network of dense cancellous bone, which provides hematopoiesis but renders the bones much stronger.[55] The bones of the front foot include the phalanges, metacarpal, and eight carpal bones arranged in two rows. The carpal bones are shortened and compressed and are an integral part of the foot (Fig. 20.8). The hindfoot is smaller than the forefoot and has an oval shape. The tarsus consists of seven bones arranged in three rows (Fig. 20.9).[58] Elephant toenails grow approximately 0.5 to 1.0 cm per month.

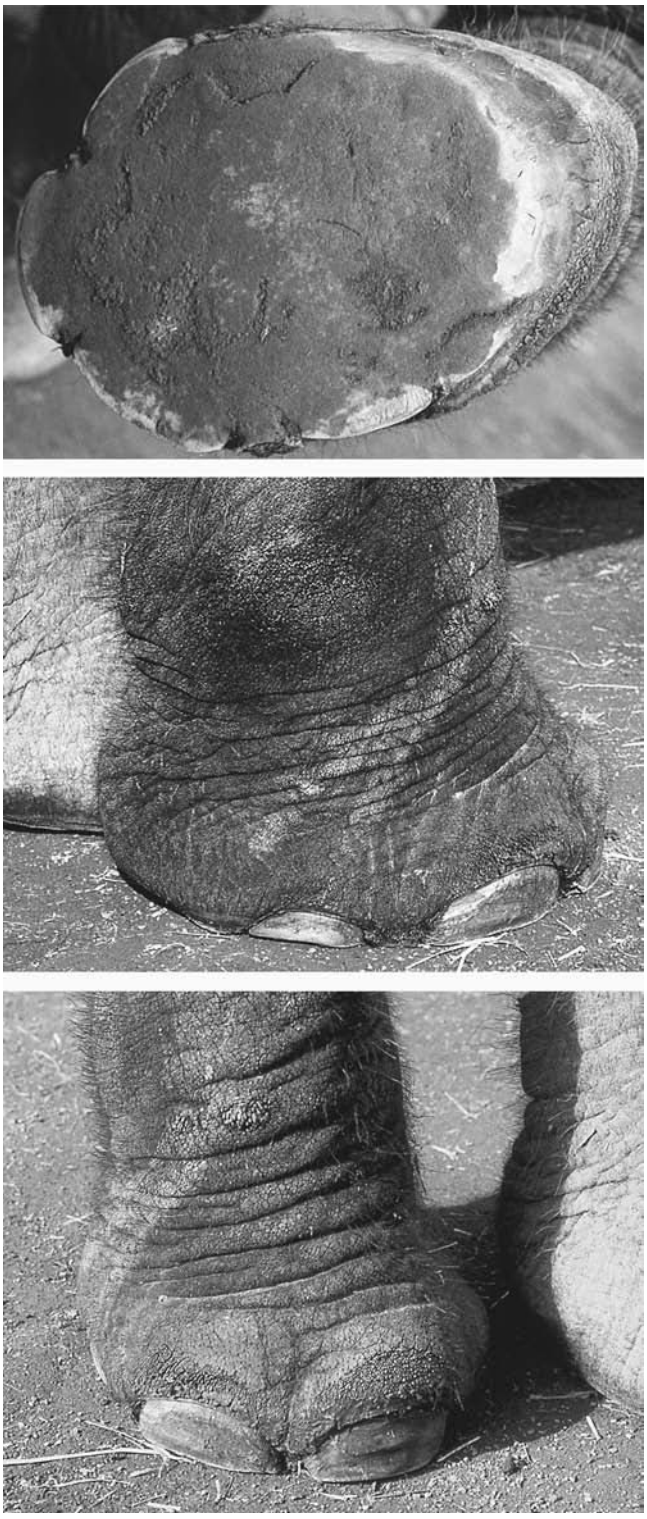

***Figure 20.2.*** *Right hindfoot of an Asian elephant. Top: slipper; Middle: lateral view; Bottom: front view.*

Each toenail has a cuticle similar to the human fingernail. Elephant toenails are not weight bearing as are those of a hoofed antelope. Two sesamoid bones lie on the distal palmar surface of metacarpals two to five. Metacarpal one has a single sesamoid bone. See Fig. 20.9.

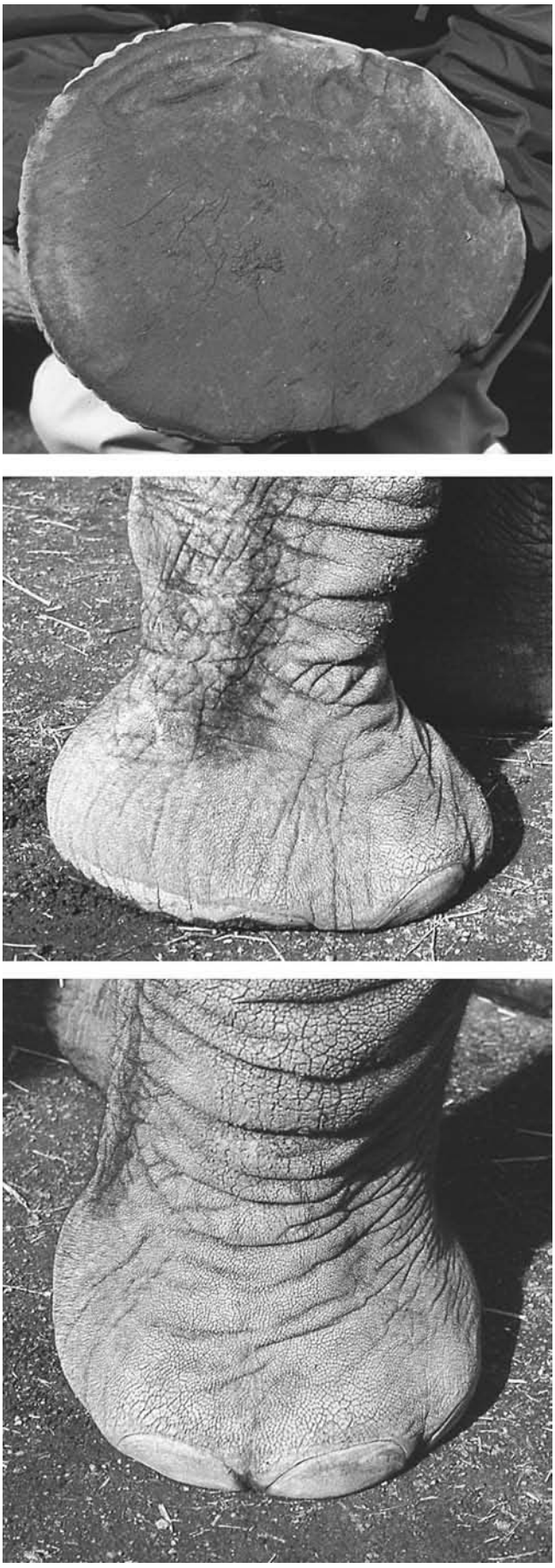

***Figure 20.3.*** *Right forefoot of an African elephant. Top: slipper; Middle: lateral view; Bottom: front view.*

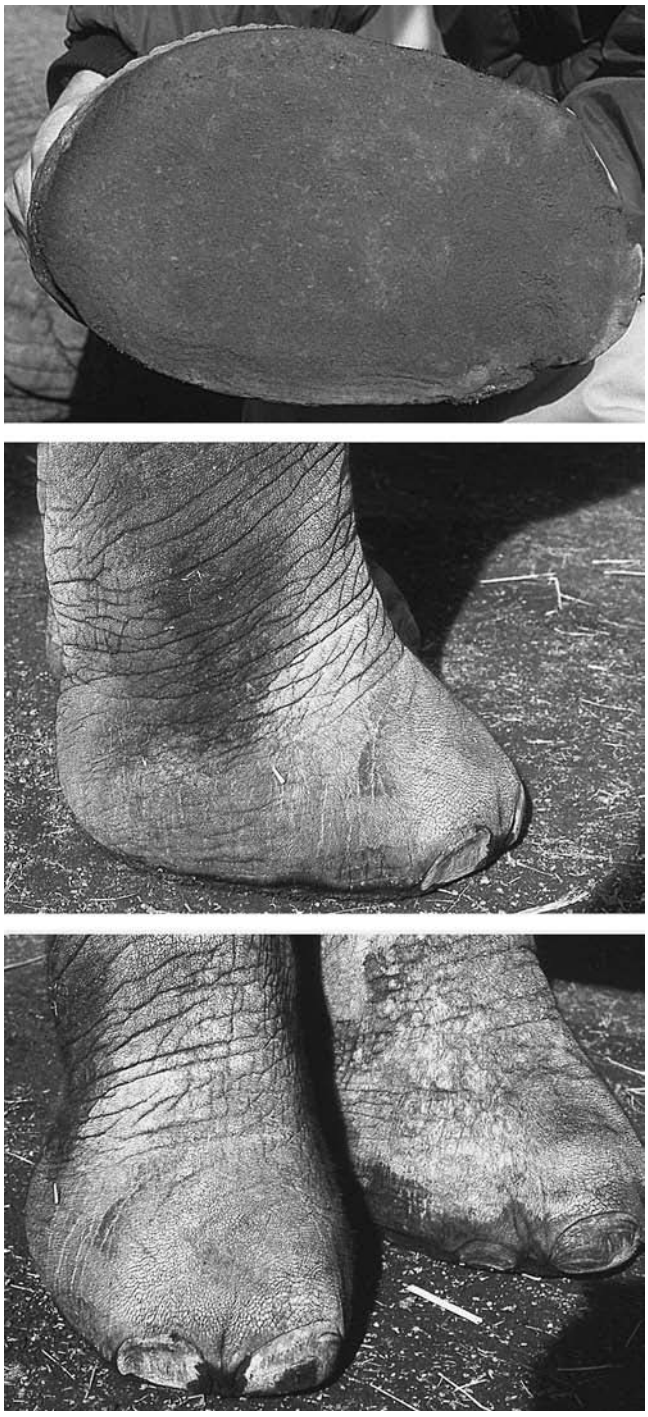

***Figure 20.4.*** *Right hindfoot of an African elephant. Top: slipper; Middle: lateral view; Bottom: front view.*

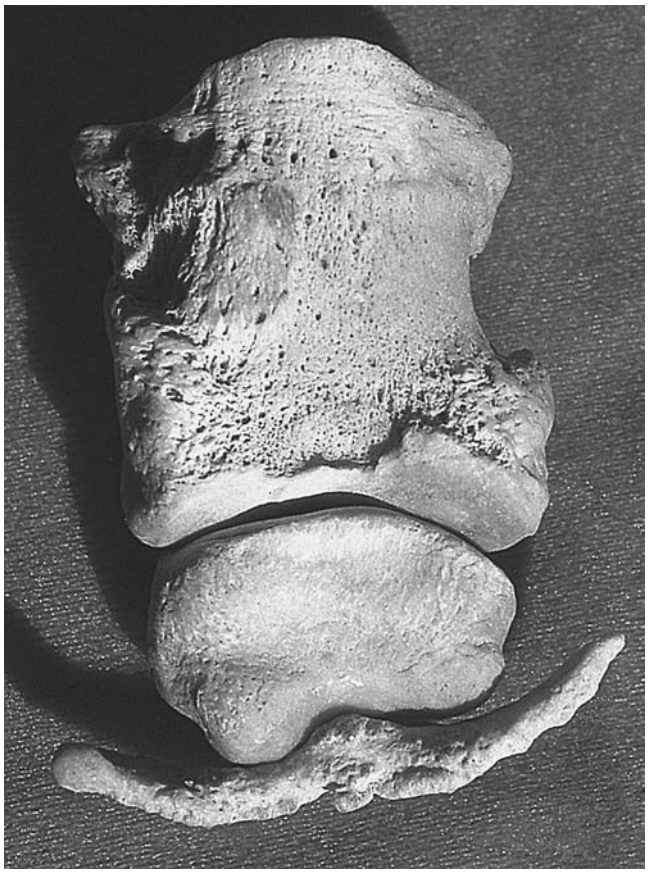

***Figure 20.5.*** *Phalanges of an elephant foot. Note winged P-3.*

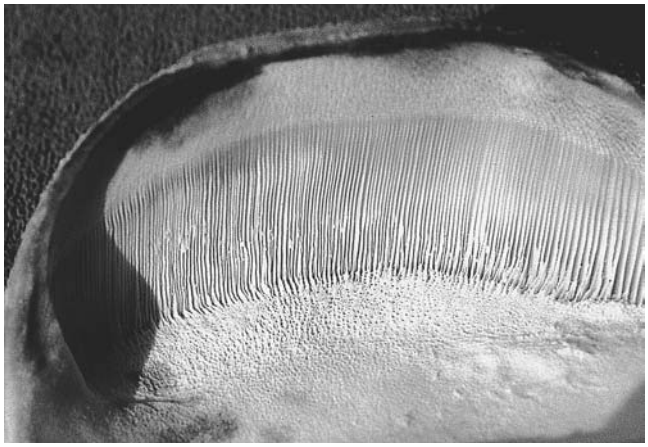

***Figure 20.6.*** *Laminae of an elephant toenail.*

The front foot has a unique cartilaginous structure (prepollex) attached to carpal bone one and metacarpal bone one by ligamentous tissue. It extends into the digital cushion and attaches to the sole slightly medial to the midline. Its function is presumed to be to stabilize the carpus and digits over the digital cushion. The hindfoot has a similar structure (prehallux) (Fig. 20.9).[30,58]

***Figure 20.7.*** *Sole of a juvenile elephant foot. Note the excessive sole that tends to entrap debris.*

Tendon and ligament arrangement in the foot is complex. Fascial sheets on the flexor surface of the metacarpals bind the digits together.[31,33,37] Flexion of the foot is provided by extensor and flexor tendons inserted on each digit as in other mammals. Lack of ability to flex the foot is an indication of either pain or ankylosis within the foot.

Elephants are semidigitigrade in the front feet, with the digits on the cranial and lateral aspects of the foot surrounding an extensive fibroelastic digital cushion (Figs. 20.10 and 20.11). The hindfoot is semiplantigrade. The metacarpal and metatarsal bones of the foot maintain a relative vertical angulation during weight bearing, but the phalanges compress the digital cushion and lie nearly horizontal when supporting the weight of the body.[33]

Muscles, tendons, collateral ligaments, synovial sheathes, vascular supply, and innervation are similar to those of other multidigit mammals.[30] Radiography of the ossification of developing bone was reported by Ayer.[3]

## PHYSIOLOGY OF THE FOOT

The foot of an elephant is a masterful piece of evolutionary development, designed to support the weight of the largest land mammal.[1,2] While standing, each foot of a large African male elephant (6000 kg) supports a weight of 1500 kg. That same elephant has an approximate slipper area of 1638.7 $cm^2$, which equates to a pressure of 0.92 $kg/cm^2$. While walking, with one foot swinging, the other feet support 2000 kg each for a pressure of 1.22 $kg/cm^2$. While ambling (modified pace), with only two

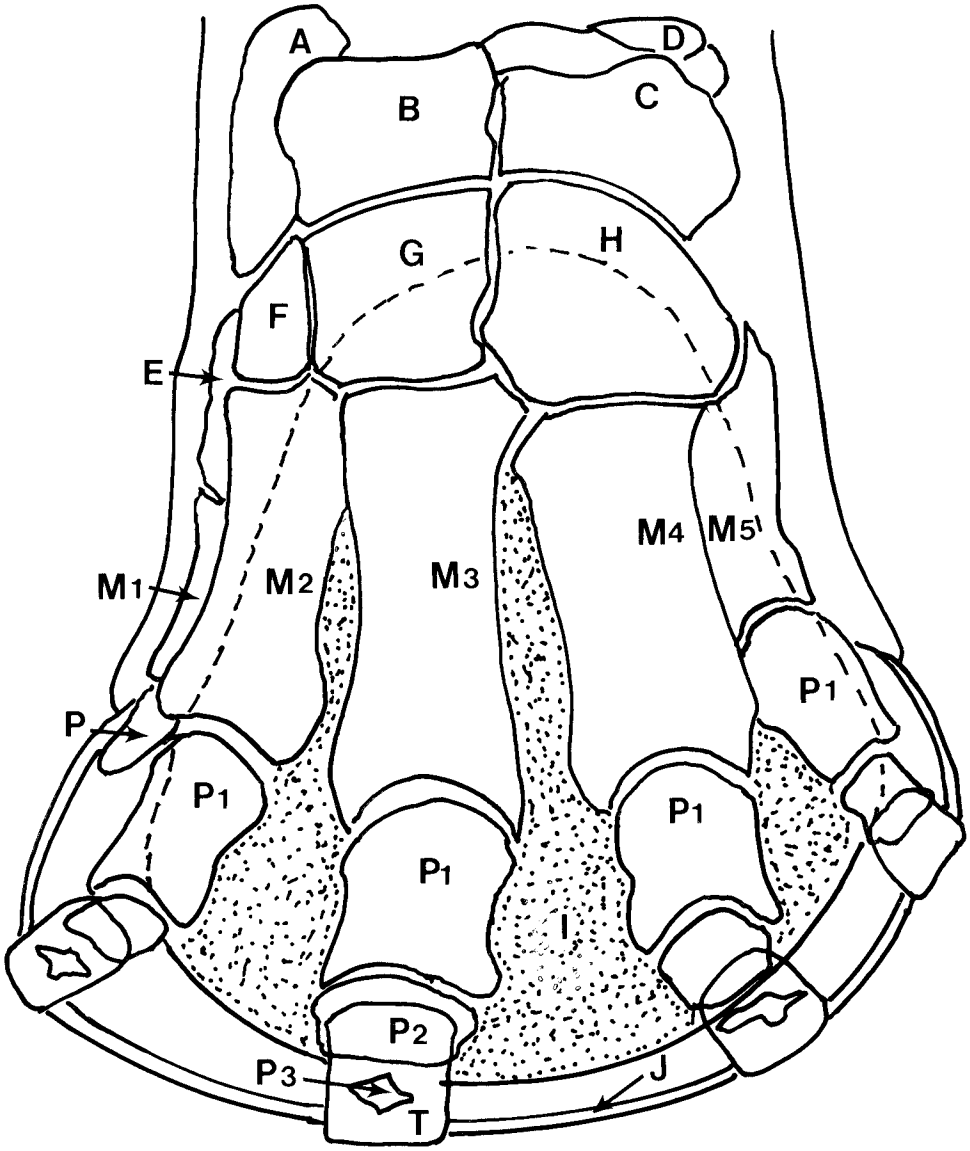


***Figure 20.8.*** *Diagram of a front view of the bones of an elephant forefoot. A) radial carpal; B) intermediate carpal; C) ulnar carpal; D) accessory carpal; E) carpal 1; F) carpal 2; G) carpal 3; H) carpal 4; I) digital cushion; J) sole (slipper), M 1–5 metacarpal 1–5, P 1–3 phalanx 1–3; S) sesamoid bone; T) toenail.*

feet supporting the body weight, each foot bears 3000 kg for a pressure of 1.83 kg/cm$^2$.

Both captive and free-ranging elephants (Asian and African), when standing and not otherwise engaged in some activity, move back and forth, alternating putting weight on one leg then the other. This is called *swaying,* and some people equate this only as stereotypic behavior. It is a natural behavior too and in the process of swaying back and forth the elephant is facilitating the circulation of blood from the distal extremities back to the heart.

Blood flows peripherally easily, but return flow must overcome the gravitational stagnation of blood in the long limbs. This is brought about by compressing the digital cushion in the foot, which acts as a peripheral pump to force blood up the leg. As the elephant alternates stepping on each foot, it facilitates circulation in the feet and legs.

In a small study conducted by the author on several elephants, weight bearing increased the circumference of the foot just above the nails from 5.0–11.4 cm or by 7.0–9.7%. As weight is applied, the digital cushion compresses and pushes peripherally, causing the increase in circumference and at the same time compressing the veins in the foot.

## ROUTINE FOOT CARE

More caretaker time is spent caring for captive elephant feet than in any other task, except feeding and cleaning. Constant attention must be given to ensure that all structures of the foot remain healthy.[10,15,16,50,51,64,65] In either free contact or volunteer contact behind a barrier, an elephant should be trained to lift each foot for inspection and place it on a pedestal, tub, or bar.[27,28] The bulk of an elephant precludes a person from manually

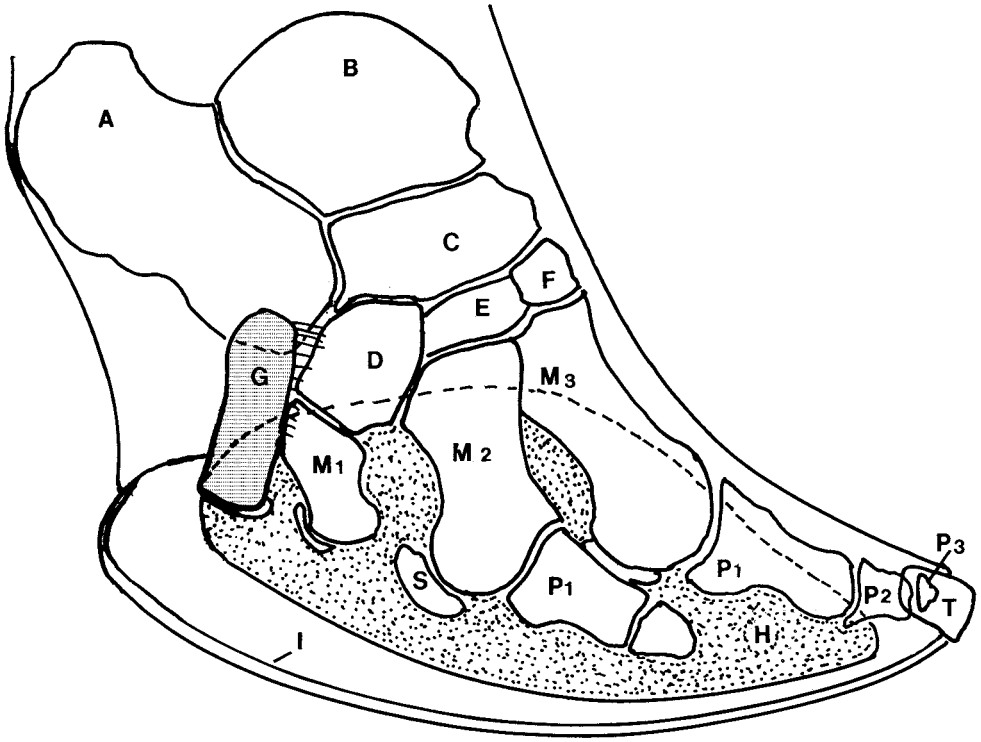


***Figure 20.9.*** *Diagram of a lateral view of the bones of an elephant hindfoot. A) calcaneus; B) talus; C) central tarsal; D) tarsal 1; E) tarsal 2; F) tarsal 3; G) prehallux, M 1,2,3 metatarsal 1,2,3, P 1,2,3 phalanx 1,2,3; H) digital cushion; I) sole (slipper); S) sesamoid bone; T) toenail.*

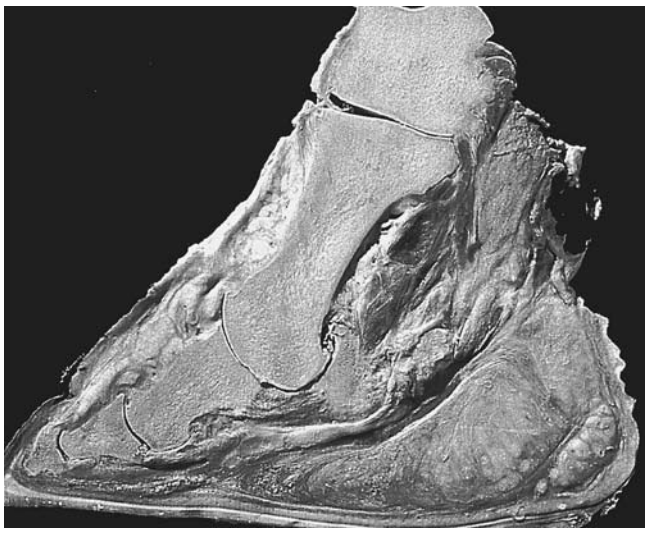

***Figure 20.10.*** *Sagittal section of an elephant forefoot.*

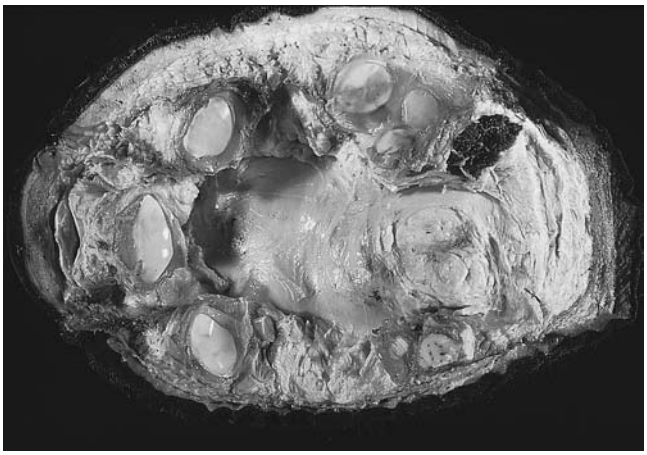

***Figure 20.11.*** *Dorsal view of the digital cushion (A), phalanges (B), and associated tissues.*

lifting the leg and holding it in position against the will of the elephant, unless a block and tackle or winch is used. Such force is not recommended.

## Components of a Foot Care Program

Components of a good foot care program include experienced staff, trained elephants, appropriate tools and equipment, proper facility design, and sufficient time for handlers to provide the necessary care.[14,24,45,46]

All elephants should be vaccinated with tetanus toxoid. In any puncture wound or cases of severe pododermatitis, a booster dose of toxoid should be administered. If the elephant has not been vaccinated previously, the author would nevertheless recommend that tetanus toxoid be administered, not tetanus antitoxin. Antitoxin is prepared from horse serum, and a risk exists for anaphylactic shock should the elephant be sensitive. Anaphylactic shock is discussed in Chapter 15.

Asian elephants are more likely to develop foot problems than Africans, the reasons for which are not known.

Perhaps evolutionary habitat may have had some bearing. For instance, African elephants rarely have toenail and cuticle problems because they evolved in open savannahs that required walking as much as 18 hours a day to obtain forage and water. The sole developed characteristics that allowed constant wearing. However, sole overgrowth must be dealt with in captive populations.

Asian elephants on the other hand evolved in moist climates with lush forage. They have less problems with sole overgrowth, but more challenges with toenails and cuticles.[46]

Any treatment regimen that inflicts pain must include an analgesic; otherwise, the elephant may resist any future attempt to handle its foot.

The feet should be inspected and cleaned daily. The bottom of the foot should be brushed with a stiff-bristled brush and checked for foreign bodies imbedded in any of the cracks or grooves of the slipper or behind the toenail. Objects may be removed with either a hoof knife or hoof pick as would be used on a horse's foot. Clean pockets associated with an overgrown slipper of fecal material or accumulated debris. Clean between the toenails and at the margin of the skin at nails and slipper and check for swelling, excessive heat, exudate, or fetid odor. If an elephant is allowed to stand in mud, water, or its own excrement for an extended period, the skin may become macerated and secondarily infected.

Check the nails, cuticle, and slipper for overgrowth and schedule appropriate trimming. It may be necessary to immobilize untrained elephants to accomplish even simple tasks, such as examining the foot or cleaning out debris. Sedation or tranquilization only encourages the elephant to resist lifting a foot. However, a tilting elephant restraint device has been used effectively without anesthesia.[52]

Radiography of the foot is discussed elsewhere in the book but it should be mentioned here that reference radiographs should be on file in case of a problem later.

## DISEASES

Foot problems constitute the single most important ailment of captive elephants.[15,16,35] Elephants in work camps in India and Southeast Asia suffer from problems similar to those of captive North American Asian elephants.[7,42,54] In one elephant camp, it was estimated that 50% of the elephants suffered from one or more foot problems (personal communication, Professor D. K. Lahiri-Choudhury, Portland, Oregon, March 20, 1998). The true prevalence is unknown because of the difficulty in collecting data.[21]

One often hears the statement that foot problems don't occur in free-ranging elephants. That is not true, because wild elephants may suffer from snare injuries, lacerations, fractures, penetration of foreign bodies, and injuries caused by stepping on land mines. Pododermatitis occurred in several wild African elephants in Kruger National Park in South Africa.[29]

Diseases will be discussed according to the organ system involved.

### Integument

**Skin.** The skin may be subjected to lacerations, foreign body penetration, contusions, abrasions, burns, and maceration. The latter is a major management concern necessitating a sound sanitation program. Prolonged irritation of the skin of the foot may lead to hyperkeratosis, particularly at the junction of the skin and sole. Such hyperkeratosis may be a prelude to cracks of the epidermis. The skin should be inspected periodically, particularly during wet weather or winter to recognize and alleviate cracking and avoid secondary infection (pododermatitis).

Hyperkeratotic skin may be thinned by gentle abrasion using coarse-gained sandpaper or a hoof rasp. The skin may be softened with a mixture (50:50) of vegetable and mineral oil. Ointments tend to accumulate dirt and debris.

#### Infectious diseases of the skin of feet.

Foot and mouth disease (FMD). FMD is a rare disease of captive elephants.[26] The details are discussed in Chapter 11. The clinical signs seen with foot involvement are as follows: The first signs noted are anorexia and lameness. The skin around the toenails and margins of the slipper may be hot, swollen, and tender. Lameness may be so severe as to cause the elephant to remain recumbent. The slipper may become undermined resulting in sloughing. Nursing care may be required for months.

Elephant pox. Elephant pox has been reported in Europe. The toenail and slipper corium may become infected, necrotic, and odoriferous. The toenails of severely affected elephants may slough.[22] Details of elephant pox and references may be found in Chapter 11.

Pododermatitis. The term *pododermatitis* is used to describe any infectious process of the foot, which may be as simple as a localized abscess or as complex as a generalized infection in and around the nails or in pockets within and beneath the sole (Fig. 20.12). A severe infection may spread to involve the bones and joints of the foot, producing septic osteitis and arthritis. A serious consequence is infection of the digital cushion.

Predisposing factors include neglect of regular nail and sole trimming, constant exposure to filth and moisture and lack of routine inspection of the undersurface of the foot. Sedentary elephants are more likely to develop foot infections than active elephants. Elephants with conformational faults tend to develop foot problems as they begin to age (30–40 years) because they walk in such a manner that unequal weight is distributed to unaffected limbs.[20]

***Figure 20.12.*** *Pododermatitis.*

An outbreak of pododermatitis occurred in free-ranging African elephants in Kruger National Park.[29] The outbreak was restricted to specific locations of harsh shrubby vegetation (mopane scrub, *Calophospermum mopane*). A prolonged drought and overbrowsing left considerable mopane stubble that apparently penetrated the slippers of the forefeet of heavy bulls (60–65% of the weight is borne on the forequarters). The elephants congregated around provided water tanks and splashed water out of the tanks resulting in mud mixed with urine and feces, providing the right milieu for infection. Signs included lameness, visible flaps of sole, and sloughing of the sole. Regional (axillary) lymph nodes became involved with swelling and drainage. Organisms isolated from the lymph nodes were the same as those isolated from the feet.[29]

Infectious agents vary from locality to locality. No studies have been conducted to ascertain the normal microflora of elephant feet. Numerous microorganisms are associated with lesions of the feet. Most of them are contaminants or opportunistic pathogens found in unsanitary environments contaminated with feces and urine. Multiple organisms may be isolated from the same lesion.

Common isolates are enteric bacteria (Enterobacteriaceae), which are gram-negative, non–spore-forming rods. They usually require an enriched medium for successful culture. They may be isolated from feces, pastures, and bedding and from the digestive tract of healthy elephants. Enteric genera may be pathogenic, opportunistic, or simply contaminants.

Enteric genera that have been isolated from foot lesions in elephants include Aeromonas, Citrobacter, Escherickia, Klebsiella, Morganella, Salmonella, and Proteus.[8,29]

*Streptomyces keratolytica*, a fungus, was associated with parasitic lesions of the feet of Asian elephants (62.5%). Other fungal organisms isolated from superficial lesions or observed in tissue sections included *Fusarium solani, Penicillium vermiculatum, Penicillium allulacecum, Paecilomyces lalanicnus, Emericellopsis synnematicolor, Cladisporum oxysporum,* and *Cryptococcus neoformans*.[8] A yeast *Candida albicans* has also been isolated from foot lesions.[5] Tables 20.1 and 20.2 list other organisms isolated from elephant foot lesions.

Clinical signs of pododermatitis include lameness, obvious overgrowth of the keratinized structures, fetid odor, and exudation from around the toenails. Rubber gloves should be worn when examining and treating suspected pododermatitis, because the odor is pervasive and persistent.

Adequate drainage of all pockets, tracts, and grooves is the key to management of pododermatitis (Figs. 20.13, 20.14, and 20.15). Foot soaking with a disinfectant solution or antibiotic therapy is superfluous if adequate drainage is neglected. The foot should be thoroughly cleaned and manicured. Trimming a severely infected foot is laborious and time consuming, and usually necessitates immobilization. Infections are common beneath and surrounding the toenails. If the elephant has not been on a routine tetanus toxoid vaccination regimen, this should be instituted immediately, because anaerobic pockets are a natural nidus for *Clostridium tetani*.

Infections involving the digital cushion are extremely difficult to treat. This tissue is relatively avascular, which slows the healing process. It is also difficult to establish drainage, because the surrounding elastic tissue expands to block a drainage window.

Special boots or sandals have been constructed to protect the dermis, keep topical medication on a lesion, provide ventilation, and deflect solid contaminants to keep the lesion reasonably clean (Fig. 20.16).[25,66] Such devices must be accepted by the elephant and involve intensive care on the part of handlers. Elephants are not likely to leave a bandage on their feet without constant supervision by a handler.

Soaking an elephant's foot in a disinfectant solution is a time-honored practice. No single solution is universally accepted by elephant veterinarians (Table 20.3). The author has used chlorhexidine, povidone iodine, Epsom salt, and copper sulfate solutions. A single, ideal regimen cannot be recommended, but it is wise to avoid concentrating the solution more than recommended by the manufacturer, because some of these solutions may be irritating to exposed tissue.

The use of local or parenteral antibiotic therapy is a matter of choice. Generally the author would not recommend antibiotics unless the bone, tendon sheath, or a joint is involved. Selection of an antibiotic should be based on culture and sensitivity.[53] A recent technique for regional digital intravenous antibiotic perfusion based on equine therapy has been employed in elephants.[60,61] Infection may begin behind the nail and migrate up the laminae to the cuticle area (gravel in a horse). A hot, tender, swollen area may be noted at the

**Table 20.1.** Characteristics of Organisms Isolated from Elephant Feet

| Organism | Gram Stain/Shape | Oxygen Requirements | Spore Status | Natural Habitat | Toxins |
|---|---|---|---|---|---|
| *Streptococcus agalactiae** (1,4) | + / cocci | Aerobe to facultative anaerobe | No spores | Commensal in upper airways and G.I. tract | None |
| Beta hemolytic streptococci,* (1,2,3,4) | + / cocci | Aerobe to facultative anaerobe | No spores | Commensal in upper airways and G.I. tract | None |
| *Staphylococcus aureus*, (1,2,3,4) | + / cocci | Aerobe to facultative anaerobe | No spores | Mucocutaneous borders, transient in G.I. tract | Exotoxins |
| *Prevotela melanogenica*, (4) (Peptostreptococcus) | + / cocci | Obligate anaerobe | No spores | Normal flora | Exotoxin |
| *Corynebacterium* spp., (1,4) | + / coccoid rod | Aerobe to facultative anaerobe | No spores | Normal inhabitant of oral cavity and G.I. tract | Exotoxin |
| *Clostridium tetani,** (3,4) | + / rod | Obligate anaerobe | Terminal spore former | Feces, soil, necrotic wounds | Exotoxin |
| *Bacillus cereus* (4) | + / rod, related to *B. anthracis* | Facultative anaerobe | Spore former | Soil, contaminated food; causes food poisoning in humans | |
| *Eggerthella lenta* (4) *(Actinobacterium*, Eubacterium) | + / Diphtheroid, related to *Corynebacterium* spp. | Obligate anaerobe | No spores | G.I. tract | Exotoxin |
| *Pseudomonas aeruginosa** (1,3,4) | - / rod | Obligate aerobe | No spores | Soil, water, transient in feces of normal animals | Exotoxin |
| *Aeromonas hydrophila* (3,4) | - / rod | Aerobe to facultative anaerobe | No spores | Soil, water | |
| *Pasteurella multicida, P. haemolytica* (4) | - / coccobacilli | Aerobe | No spores | Mucous membranes of oropharyngeal region | Exotoxin |
| *Mannheimia haemolytica,* (4) (*Pasteurella*) | - / coccobacilli | Aerobe | No spores | Mucous membranes of oropharyngeal region | Exotoxin |
| *Dichelobacter nodosus** (Fusiformis, Bacteroides) (4) | - / rod | Obligate anaerobe | No spores | Normal flora of skin; the infectious agent of ovine foot rot | Exotoxins |

*= Important pathogen; G.I. = gastrointestinal; 1 = Boardman 2001; 2 = Chatterjee 1984; 3 = Gage 1997; 4 = Keet 1997.

top of the nail. The swelling may rupture, and an odoriferous exudate is discharged.

**Toenails.** Elephant toenails require constant attention from caretakers to prevent hidden infection from progressing to untreatable osteomyelitis.

Overgrowth. Toenails grow primarily at the germinal epithelium at the root (top) of the nail, at a rate of approximately 0.5 to 1.0 cm per month. If the enclosure substrate is not abrasive or the elephant does not walk as much as it should, it may be necessary to remove excess nail every 2–3 months. Trimming is performed using equine hoof nippers and a hoof rasp (Fig. 20.17).

Neglected toenails may become infected (Fig. 20.18), become deformed, or grow laterally and penetrate into adjacent skin or sole. This causes an inflammatory response (perionychia) similar to that caused by a human ingrown toenail. Signs include lameness, evidence of the embedded toenail, sensitivity to palpation, exudation, and formation of granulation tissue. Elephant granulation tissue presents as a whitish, friable mass.

Toenail cracks. Horizontal and vertical cracks may occur, but vertical cracks are more common (Fig. 20.19).[38,40,47] Cracks may begin at the cuticle and extend distally to the tip, or they may begin at the bottom and extend proximally. Cracks may be superficial, being confined to the keratinized nail, or extend into the corium, which causes more discomfort for the elephant.

The etiology of toenail cracks is unknown, but it may include factors such as nutrition, genetics, overgrowth, and trauma. When a crack develops, it is exacerbated by the expansion and contraction of the foot during ambulation.

Treatment of superficial cracks may require little more than grooving with a hoof knife to determine the depth of the crack. Avoid rasping the outer surface of the nail with superficial cracks, because this removes the protective periople of the nail. Cracks into the corium necessitate more aggressive treatment. Groove the crack with a sharp hoof knife or groover until all vestiges of the crack (black tracts) are opened. As the corium is approached, a gauze sponge soaked with 2% lidocaine should be applied to the crack and left in place momen-

**Table 20.2.** Microorganisms Isolated from Foot Infections and Abscesses in Elephants*

| | Gram Stain | Shape | | Oxygen Requirements | | | Motility | | | Pathogenicity | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Microorganism | Neg. | Rod | Coccus | Aerob. | Anaer. | Facult. | Anaer. | Motile | Nonmotile | Primary | Opport. | Comment |
| *Escherichia coli* | | X | X | | X | | | X | | X | X | Zoonosis |
| *Proteus vulgaris* | | X | X | | | | X | X | | | X | Cultures overgrow other organisms |
| *Pseudomonas aeruginosa* | | X | X | | | X | | X | | | X | Zoonosis |
| *Fusobacterium necrophorum* | | X | X | | | X | | | X | | X | |
| *Dichelobacter (Bacteroides) fragilis* | X | | X | | | X | | | X | X | X | Zoonosis |
| *Dichelobacter nodosus* | X | | X | | | X | | | X | X | X | Also isolated from regional lymph nodes |
| *Beta hemolytic streptococci* | X | | | X | X | | | | X | X | X | Zoonosis |
| *Streptococcus agalactiae* | | X | | X | X | | | | X | X? | X? | |
| *Staphylococcus aureus* | X | | | X | | | X | | X | X | X | Grow in clusters; zoonosis |
| *Pasteurella multocida* | | X | X | | | | X | | | X | X | Bipolar staining |
| *Aeromonas hydrophila* | | X | X | | | | X | X | | | X | |
| *Enterococcus zymogenes* | X | | | X | | | X | X | X | | X | |
| *Salmonella* spp. | | X | X | | X | | | | X | X | X | |
| *Klebsiella* spp. | | X | X | | | X | | | X | X | X | Zoonosis |

*Holt, J.G., Krieg, N.R., Sneath, P.H.A., Staley, J.T. and Williams, S.T.1994. Bergey's Manuel of Determinative Bacteriology, 9th ed. Baltimore, Williams and Wilkins.

***Figure 20.13.*** *Sole of an adult elephant's foot with excessive growth, producing grooves, ridges and pockets.*

***Figure 20.14.*** *Trimming the sole with a drawing knife.*

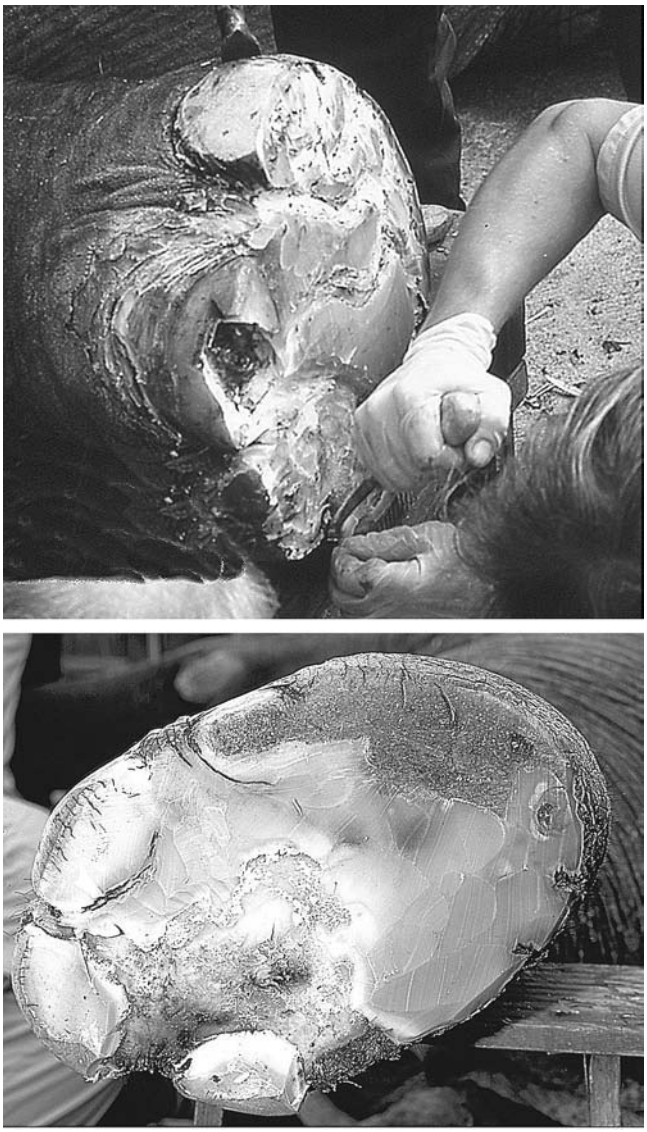

***Figure 20.15.*** *Trimming a foot. Top) Using a hoof knife; Bottom) extensively trimmed.*

tarily to provide local anesthesia. Infliction of pain should be avoided or it is difficult to proceed.

Deep cracks require thinning of the edges to alleviate the mechanical pressures that tend to force the crack open. This is done by rasping the surface of the nail to feather the crack edges to the corium. At the same time, the distal end of the nail should be shortened as far as possible to prevent ground pressure. The corners of the nail should be rounded. If the crack has not reached the cuticle, a horizontal groove at the top of the crack may discourage further cracking.

The author has had no success with clamps, clips, staples, screws, or tension wires, as used in horses. None of these can withstand the tremendous pressures exerted on the toenail by the expansion of the elephant's foot. A protocol using epoxy resin and fiberglass fabric bonded to the nail with vertical grooves produced by a hobby drill (Dremel Moto-tool) has been reported. This is a procedure similar to one performed routinely on the fractured carapace of chelonians.

***Figure 20.16.*** *Sandal on an elephant's foot.*

In all cases, the healing process is prolonged and interrupted with periodic exacerbations.

Onychia. Inflammation or infection of the toenail bed is usually the result of failure to clean behind the nail regularly. Anaerobic conditions are set up, and infection spreads in the path of least resistance, which is upward through the laminae to rupture at the top of the nail (equine gravel). Clinical signs are lameness; a hot, painful swelling; or a draining tract at the top of the nail. Examination of the bottom of the nail reveals a black tract extending dorsally. A severe onychia may cause separation of the nail from the corium with a subsequent slough.

A differential diagnosis must consider the fluid pockets that occur at the base of toenails beneath the cuticle. Such pockets are filled with sweat, not pus.

Treatment involves trimming out the black tract and packing it with a disinfectant-saturated gauze pad to prevent debris from being repacked into the void, Table 20.4. The pack should be changed at least twice daily. It is also recommended that a sandal be affixed to the foot.

Cuticle. The cuticle is the keratinized skin at the junction with the nail. Elephant cuticles should be manicured regularly. Some elephants' cuticles seem susceptible to excessive growth (hangnails), but inflammation causes proliferation. Thus animals kept standing in mud or their own excrement are most likely to develop problems. The keratinized cuticle becomes hardened and eventually cracks, causing formation of painful hang-

**Table 20.3.** Solutions Used to Soak Elephant Feet

| Generic Name | Trade Name | Source | Indications | Mixing Directions | Comments |
|---|---|---|---|---|---|
| Magnesium sulfate, USP, $Mg\ SO_4\ H_2O$ | Epsom salt | Any drugstore or pharmacy | A concentrated solution of Epsom salt is hypertonic and draws fluid from tissue; used for local inflammation, cellulitis, arthritis, and contusions | For an elephant foot, 225 g (0.5 lb) of Epsom salt in 2 l (2 quarts) hot water; allow water to cool | |
| Chlorhexidine diacetate | Nolvasan solution, 2% chlorhexidine | Fort Dodge Laboratories, 800 5th St., N.W. (P.O.B. 717), Fort Dodge, IA 50501 | General disinfectant | 250 ml (9 oz) of the 2% stock solution to 1.0 l (1 quart) of clean water = 0.5% chlorhexidine | Not effective against *Pseudomonas* spp., or gram-positive cocci |
| Povidone-iodine solution; other names include iodophore, tamed iodine | Vedadine, 10% stock solution | Vedco, St. Joseph, Missouri, USA | General disinfectant | May use undiluted or for irrigation or soaking; dilute stock solution 1:10 (400 ml to 3.79 l (1 gal) | May dilute up to 1:100 |
| Copper sulfate | Copper sulfate | Veterinary supply companies | Disinfectant | 50 g to 1 liter = 5% solution | Caustic in high concentrations |
| Sodium hypochlorite (NaOCl) | Clorox, 6% solution | Any grocery store | Powerful oxidizing agent and disinfectant | Use 0.25% solution for soaking; 155 ml bleach to 3.7 l (1 gal) water | Will bleach clothing |

Formula for calculating dilution of a stock solution to a therapeutic solution:
the % of the active ingredient in the stock solution $\times X$ = the desired ultimate % $\times$ the volume desired.
$5\% \times X = 0.25\% \times 1000$ ml
$X = 250/5 = 50$ ml of 5% stock solution in 750 ml of water

***Figure 20.17.*** *Rasping a toenail.*

***Figure 20.18.*** *Chronically infected toenail.*

nails (Fig. 20.20). Furthermore, the crack is a portal for infection.

A condition that may develop in some elephants is an extension of an overgrowth of the cuticle, which appears as a thickening of the internail skin. Sometimes it is described as an interdigital callus, similar to that seen in the bovine foot. The interdigital skin should be flexible and free of infected pockets. If this skin becomes heavily keratinized and hardened, it acts as a foreign body and causes discomfort when walking by pinching the skin between contiguous nails.

***Figure 20.19.*** *Toenail cracks.*

Fluid-filled pockets may be found beneath overgrown cuticles. Sweat glands are concentrated in the skin associated with the cuticles. Overgrowth of the cuticles may put pressure on the ducts and obstruct the discharge from the glands, causing a buildup of the fluid. Elephant caretakers call these "blisters" or "blebs." Fluid pockets may rupture and become infected. Management of the fluid pocket requires returning the cuticle to normal architecture.

Routine toenail maintenance includes trimming the cuticle and thinning the interdigital skin, if necessary, by use of a hoof rasp or shaping with a hoof knife. Severely overgrown cuticles may be trimmed with an equine hoof nipper, but it may be necessary to cut the cuticle back in stages to avoid hemorrhage of the skin.

Contusion of the toenail. A blow to the surface of the toenail may produce a contusion or hematoma of the laminae, similar to the injury caused by hitting one's fingernail with a hammer. Excessive exercise with elongated toenails may also traumatize the nails.

Soaking the feet in cold water may help stop extravasation of plasma or blood and soothe pain. Administration of an analgesic, such as butorphanol, may also be indicated. See Chapter 15.

**Sole (slipper, pad).** The external keratinized layer that produces the flexible slipper on the bottom of the elephant foot is formed from a deep germinal epithelium. The arrangement is similar to that of the sole in the horse. Growth is from 0.5 to 1.0 cm per month. If the sole does not wear sufficiently, it becomes thickened, and because the thickening is seldom uniform, defects are produced that lead to pocket formation and overgrowth, which sets the stage for infection. The result may be a condition similar to thrush in and around the frog of a horse's hoof.

Other problems include foreign body penetration, lacerations, development of cracks or fissures, and generalized maceration with softening of the keratin. All these predispose to subsole abscessation or pododermatitis.

Clinical signs are similar for most conditions, including lameness, reluctance to move, and flinching when pressure is applied over an inflamed area. In more severe cases, there may be swelling, heat, erosions, ulceration, and granulation tissue proliferation. Tetanus is a potential sequel to abscessation.

Abrasion of the sole. If thinning of the sole is noticed, watch the elephant's behavior. If closely observed, it may be determined that the elephant constantly turns in a specific location and in the same direction (stereotypic behavior). This causes excessive wear on a specific area of the sole.

Another predisposing factor is a conformational fault or an injury that causes the elephant to walk in such a manner as to produce excessive wear on a segment of the slipper. An elephant may become habituated to pawing with one foot, which may wear a toenail and the sole excessively. A shuffling gait brought about by arthritis may also produce uneven wear.

Creativity is required to solve this problem, possibly including changing the floor surface, redirecting activities, and using protective devices on the foot, such as repeated application of duct tape or the use of a sandal.

Trimming the sole. The sole is a broad, relatively flat surface, which makes trimming with conventional equine or bovine hoof-trimming tools difficult; however, persons with responsibilities to provide routine maintenance of elephant feet will have a variety of tools from which to choose. It is wise to learn how to use tools that are available. Tools for elephant foot care include a hoof knife, hoof rasp, hoof groover, Buffalo brand hoof groover and knife combination, Xacto knife (X router blade, No. X161, a grooving blade), drawing knife (spoke shaver), equine hoof nipper, electric rotary grinder, Swiss cutting knife, curette, stiff-bristled brush, rat-tailed file, fine bastard file, and sharpening stone or hone (Fig. 20.21).

Power grinders are generally not recommended except for skilled, experienced foot caregivers. Grinders speed

**Table 20.4.** Antimicrobial Agents Applied to Lesions of the Foot

| Generic Name | Trade Name | Source | Indications | Mixing Directions | Comments |
|---|---|---|---|---|---|
| Copper sulfate $CuSO_4$ | Bluestone, blue vitriol; a blue granular powder | Garden supply store, pharmaceutical company | An astringent in dilute solution | As an astringent, a 1.0% solution (10 gm/l of water | Caustic in concentrated solution |
| Chlorine-dioxideoxychlor complex | Ciderm liquid and gel | ARCO Research Inc., SUNY Farmingdale, Conklin Hall, Farmingdale, NY 11735 | A powerful oxidizing agent; also an excellent antimicrobial and deodorant | Use as supplied | |
| Dilute acetic acid | Vinegar, 5% acetic acid | Grocery store | Used as an antimicrobial and cleansing solution | Use as supplied or dilute to 1% (200 ml 5% vinegar to 800 ml water) | Glacial acetic acid is 36–37% acetic acid and is caustic |
| Dimethylsulfoxide | DMSO | Veterinary supply companies | Used as a solvent to facilitate movement of other medications into tissues | Use as supplied | Causes a disagreeable odor in the breath of the animal; wear rubber gloves |
| Formalin, 10% formaldehyde | Formalin | Veterinary supply companies | Powerful disinfectant | 2.5% solution (250 ml of 10% formalin to 750 ml water) | Quite caustic |
| Hydrogen peroxide ($H_2O_2$); colorless, odorless liquid | Peroxide, hydrogen peroxide, 3% solution | Any drugstore or pharmacy | Powerful antiseptic when in contact with tissue fluids, causing foaming and cleansing | Use as supplied | Do not inject into puncture wounds or into closed cavities |
| Ammonium ichthyolsulfonate, bitumen sulfonatum, ichthammol | EquiPhar | Vedco | Slightly irritant; draws abscesses to a head, reduces swelling and is somewhat antiseptic | 20% ointment; a mixture of a product of the distillation of bitumen with lanolin and petrolatum; contains 10% sulfur | |
| Copper naphthenate, 37.5% | Kopertox | Fort Dodge Laboratories, Fort Dodge, IA | Wound protectant and disinfectant; apply daily following cleansing of the wound | Use as supplied | Can be removed from hands and clothing with lighter fluid |
| Zinc oxide (ZnO) | Zinc oxide (ZnO); a white to yellowish-white powder | Veterinary supply companies | Antiseptic, soothing, will protect skin from exudates | Made into a 20% ointment | Ointments may attract dirt and debris |
| Potassium permanganate $KMnO_4$ | Potassium permanganate | Mallinckrodt Chemicals | Antiseptic | 1:1000 concentration (1 g $KMnO_4$ in 1 l water) | Rarely used in current veterinary medicine |
| Sucrose | Granulated sugar | Any grocery store | Hydroscopic, will desiccate organisms, stimulates wound healing | Apply as supplied | Sugar has been used effectively in both human and animal wound treatment |
| Polyhexosamine polymer from deacetylation of chitin | Chitosan flakes | Vanson Inc., Redmond, Washington | Stimulates wound healing | 1% chitosan and 1% glacial acetic acid in water | |

the work and diminish the labor involved in trimming, but if they are used unwisely, the sole and toenails may be trimmed excessively and sensitive tissue be overheated.

A critical factor is the correct sharpening of cutting tools. Hoof knives and groovers need to be sharpened on the inside of the hook.

For trimming the surface of the slipper, the author recommends the use of a drawing knife (spoke shaver), which is a nonflexible blade mounted between two handles (see Fig. 20.14). Drawing knives have limited use in modern woodworking, so it may be necessary to special-order one from a hardware store. The drawing knife should be pulled steadily toward the operator. It is easy to cut too deeply and expose the corium. One should

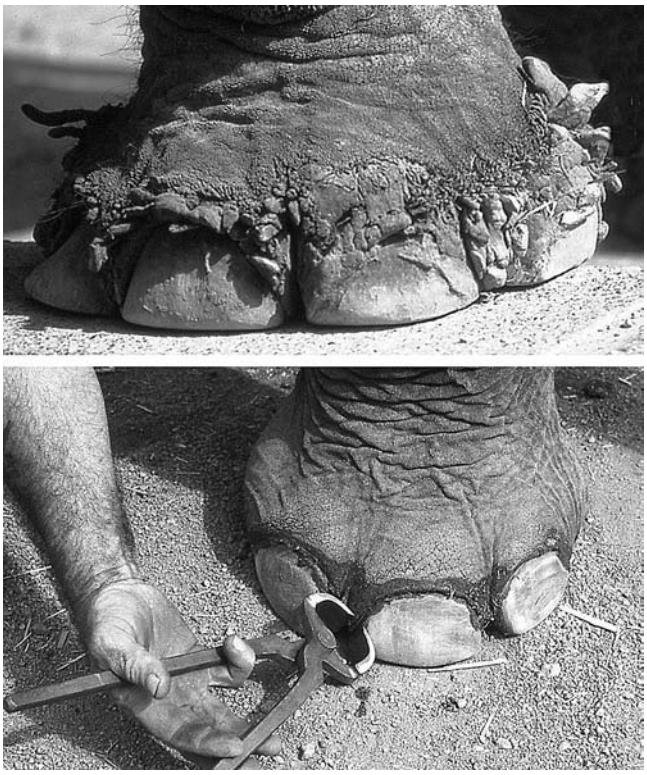

***Figure 20.20.*** *Cuticle overgrowth (hangnail). Top: numerous hangnails; Bottom: trimming with an equine hoof nipper.*

trim cautiously, shaving off one thin sheet at a time. Sight of a yellowish-pink keratin indicates closeness to the corium.

Severely overgrown soles may present a mosaic of ridges and grooves, setting the stage for numerous pockets. Normal soles are from 4–12 mm thick, varying with individuals and the amount of activity. Grooves should be beveled to discourage lodging of debris, but overzealous trimming of the sole should be avoided. It is not necessary or desirable to eliminate all the grooves and ridges. The drawing knife should be used in conjunction with a sharp hoof knife to pare out pockets and grooves to healthy keratin. Black tracts must be eliminated, and all chalky sole should be removed. Severely overgrown soles may require frequent, repeated trimming to return the foot to a healthy condition without cutting into the corium. However, the greatest mistake made in foot care in elephants is not being aggressive enough in providing drainage for infected pockets on the sole surface. An elephant that has had overgrown soles for a considerable time may walk daintily following trimming.

Contusion (bruise) of the sole. A contusion results from a rupture of blood vessels in the corium beneath the sole. Predisposing factors include stepping on a stone or other object that becomes a point source when weight is applied to the foot, walking on gravel or broken-up pavement, walking in muddy areas in cold climates that have frozen clumps of mud, and excessive trimming of the sole. The author has watched circus elephants during a walk to the performance site that walk slowly on questionable surfaces, watching where they place their feet, and pick up the pace when the surface is smooth.

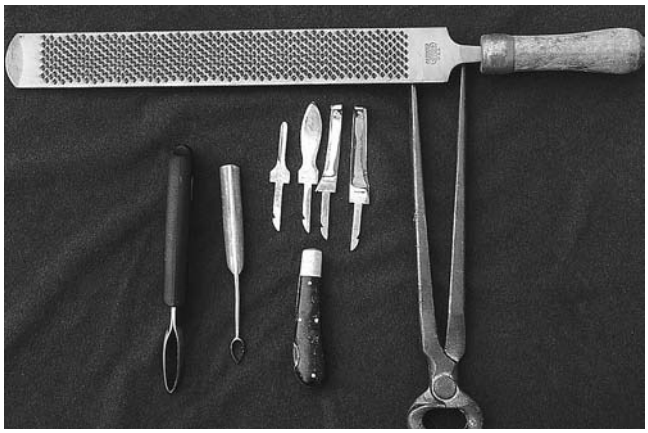

***Figure 20.21.*** *Tools used for pedicure of elephant feet.*

Clinical signs may or may not exhibit lameness. Evidence of a contusion on the slipper surface may not appear until the sole has grown out, leaving a reddish stain. If a contusion is suspected, digital pressure may cause the elephant to flinch. A contusion may result in a seroma beneath the sole and may become infected, causing an abscess.

Treatment of mild contusions may be unnecessary. If digital pressure finds an extremely sensitive spot, the elephant should be rested from any walking activity and the foot checked daily. The area over the sensitive region may be shaved carefully to relieve pressure, but the corium should not be exposed. Nonsteroidal analgesics may be used for a few days (less than a week). If an abscess is suspected, an ultrasound examination of the sole may disclose a pocket of exudate, in which case the abscess must be drained.

Subsole abscesses. Abscesses may be focal or diffuse. Severe diffuse subsole infection may undermine the sole, necessitating removal of a section of the sole or in extreme cases most of the slipper. The infection is usually located between the slipper and the germinal epithelium, so a new keratinized sole will form once the infection has abated.

Ultrasonography may be used to determine subsolar abscesses and undermining.[41] Remove as much of the detached sole as possible to provide adequate drainage and penetration of disinfectant solutions. Protect the sensitive corium with dressings—or better still, a boot.

## Musculoskeletal System

**Trauma.** The bones of the foot may be traumatized by other elephants or, more commonly, by tethering acci-

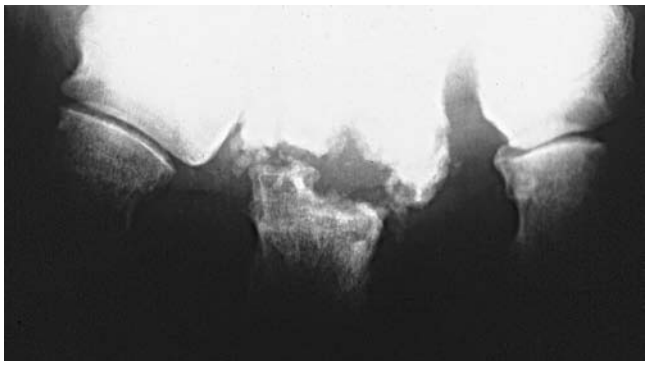

***Figure 20.22.*** *Osteitis of the phalanges.*

dents. Clinical signs may be dramatic because the elephant may refuse to put weight on the limb. Heat and swelling may or may not be evident. Radiography should be considered in a nonresponsive lameness that apparently involves the foot; see SECTION II, "Radiography," of Chapter 13.

Unfortunately, it is not possible to place the foot in a cast because of foot expansion when weight is exerted on the foot. Extended restriction of exercise is recommended. Analgesics may be indicated, but overuse of these may encourage the use of the limb when the elephant should be resting.

**Septic osteitis (osteomyelitis).** Elephant limb bones do not have a marrow cavity,[55] so technically they don't develop osteomyelitis. Septic osteitis of the phalanges is the most serious condition affecting the foot (Fig. 20.22).

Predisposing factors. Penetration of a foreign body into the bone (glass, nails, wire, wood sliver) may result in osteitis. More commonly, osteitis occurs as a result of improper management of a soft tissue infection in the foot that spreads to adjacent bones.

Clinical signs. Lameness may be subtle or pronounced. Usually there is a draining fistula near one of the toenails.

Diagnosis. Survey radiographs of the feet should be on file for comparison. When septic osteitis is suspected, the foot should be reradiographed for evidence of bone involvement. Usually P-3 and P-2 are the phalanges involved.[18,23] Particular attention should be paid to P-3 because this bone may have variable normal appearance and may appear as a thin horizontal sliver of bone with fractures present[17]. Osteitis will present with the typical starburst degeneration of bone. A fistulogram may provide definitive diagnosis.

Management. It is tempting to begin a course of broad-spectrum antibiotics, but experience with osteomyelitis in other species indicates that this is futile unless the infected bone is removed surgically. The surgery is difficult, and the aftercare required is intensive and prolonged.[9,12,17,60,61]

**Infective (septic) arthritis.** Infective arthritis may accompany septic osteitis as the infection spreads proximally. It may also be caused by foreign body penetration of a joint or may have a hematogenous origin, especially in neonates. Sepsis may rapidly cause erosion and destruction of the joint cartilage.

Predisposing factors. Joint trauma may predispose to organisms that cause another disease in the elephant. Umbilical infection (navel ill) is another source. Hypogammaglobulinemia may contribute to septic arthritis in calves.

Clinical signs. Septic arthritis is one of the most painful conditions of the skeletal system. An elephant is reluctant to place any weight on the affected limb and may remain recumbent if capable of doing so. In any species, septic arthritis, fractures, and an open joint are conditions suspected when an animal refuses to place weight on a limb. Heat, swelling, and pain associated with palpation or manipulation are cardinal signs.

Diagnosis. Severe lameness should prompt the clinician to take radiographs of the foot; however, periosteal reaction and osteitis may not be evident in early stages. The definitive diagnosis may rely on aspiration of synovial fluid from the infected joint space. Aspiration should be performed aseptically so that the fluid may be cultured. Not all infected joints yield an organism because the infection is localized in the synovial villi and periarticular tissue. The fluid may be cloudy, purulent, or hemorrhagic, with decreased viscosity and an increased WBC above 33,000 per $mm^3$.

Management. The diagnosis of septic arthritis is an emergency, and treatment should be designed to eliminate the infective organism and remove the harmful products of synovial inflammation and fibrin that can damage the articular cartilage.[62] Broad-spectrum antibiotic therapy should begin immediately, even before the results of a sensitivity test are returned. Lavage of the infected joint with physiologic saline solution or other solutions via arthroscopy is being used in equine medicine.[62] No reports are currently available for lavaging a septic joint in elephants. Should such treatment be indicated, it is recommended that an equine surgeon at a veterinary school be contacted for the latest methodology.

Regional perfusion with antibiotic solutions has been used in elephants.[39,60]

**Mycoplasmal arthritis.** Mycoplasmal arthritis is discussed in Chapter 11.

**Septic tendosynovitis.** Multiple flexor and extensor tendons and associated synovial sheath are present in the foot. Trauma (contusion) to any of the tendons may cause tendonitis. Lacerations and foreign body penetrations may also affect tendons.

Predisposing factors. Tendosynovitis is usually secondary to other primary infections within the foot. It may also be a sequel to surgical removal of a septic osteitis.

Clinical signs. Lameness, heat, swelling, and tenderness to palpation are indications of tendosynovitis of the extensor tendons. Flexor tendons lie deep within the foot and are more likely to be the tendons affected secondarily. Swelling may compromise circulation, resulting in lower limb edema. Synovial fluid may drain from a lacerated tendon.

Diagnosis. Clinical signs are primary. Ultrasonography is a diagnostic tool used in equine medicine, but no reports have been published on its use in elephants.

Management. Treatment is the same as for septic arthritis.

**Degenerative joint disease (DJD, osteoarthritis).** Osteoarthritis may be considered as a group of disorders characterized by a common end stage, which is a progressive deterioration of the articular cartilage, accompanied by changes in the bone and soft tissues of the joint.[32] DJD is a major cause of disability in captive elephants and thought by some to be the result of poor management practices with captive elephants (Fig. 20.23). However, arthritis has been identified in prehistoric mastodon skeletons. As in horses, DJD in elephants is not likely a single specific disease, but different conditions that have the same conclusion. DJD may affect any of the limb joints, but in this section emphasis is given to foot joints.

Predisposing factors. This is a controversial subject. Lack of exercise, housing on hard surfaces, and tethering are frequently brought forward as causes of DJD, but aging and wear and tear (trauma from performing repetitive actions) may have a bearing on the development of articular cartilage deterioration. The elephant's bulk and lack of angulation of the limb bones promote concussion of articular cartilage. Concurrent conformation defects or injuries that cause an elephant to alter its normal gait and change the pressure patterns within joint surfaces may have an influence. Certainly this has been shown to be a factor in human DJD.[32]

Clinical signs. Nonworking elephants may or may not exhibit lameness. Astute observation may detect subtle changes in gait, or the elephant may have been noticed to be less active recently. DJD was not detected in an elephant in a small zoo in California until a previously submissive enclosure mate became dominant and knocked the elephant down and pushed her under the railing of a fence. Although extricated from beneath the fence, she was unable to rise until lifted to her feet with a crane. Radiographs then detected multiple joint DJD.

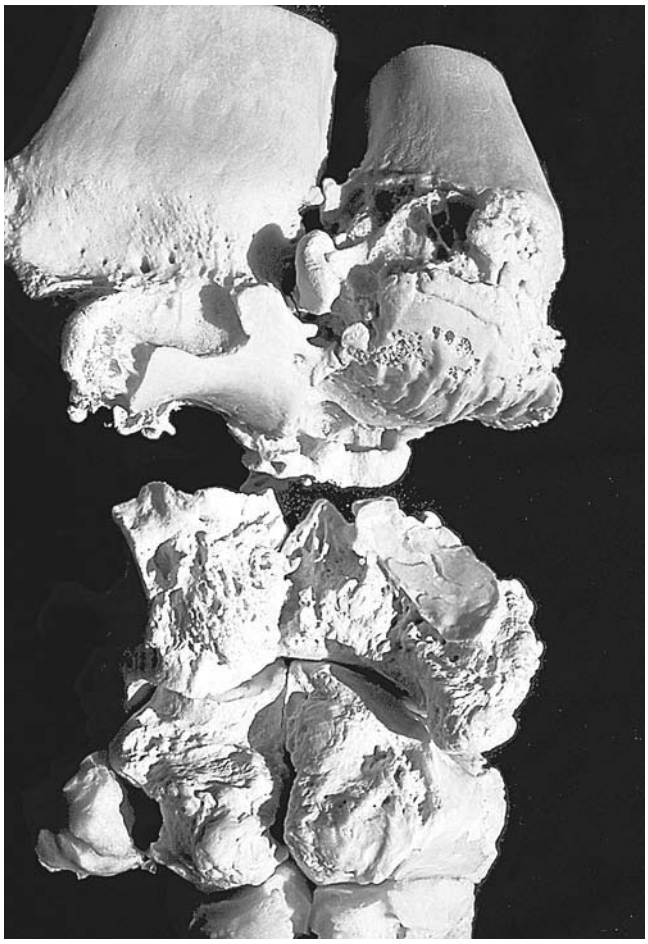

***Figure 20.23.*** *Degenerative joint disease of the elephant carpus.*

Diagnosis. Radiography is the primary means of diagnosing DJD. The characteristic radiographic findings in DJD include narrowing of the joint space, subchondral bone sclerosis, marginal osteophyte (joint mice), and periosteal bone proliferation.[32]

In acute cases, motion of a joint may be diminished (flexion of the foot joints is minimal at best, so this requires astute observation), and there may be swelling and heat over the front of the foot. Later, heat and swelling may be less evident. Arthroscopy is a definitive diagnostic tool in horses,[32] but it has not been described for elephant foot DJD.

Management. The regimens for treatment of DJD are almost as numerous as the people who implement treatment. This is understandable because the type of DJD and the stage of disease at which a diagnosis is made

vary. No sound studies for treating foot DJD in elephants have been forthcoming.

In horses, treatment is based on three principles. First, prevention or treatment of any primary cause. Second, treatment of active soft tissue disease contributing to articular cartilage degeneration. And third, treatment, if possible, of the cartilage degeneration (cartilage curettage, osteophyte removal).[32] A fourth principal might be management of pain.[4] See Chapter 15 for details. The author recommends reading the reference and/or contacting an equine surgeon at a veterinary school.

**Fractures.** Fracture of the foot bones is rare but the diminutive third phalanx may suffer multiple transverse fractures that apparently cause no clinical signs and have an unknown etiology.

**Ankylosis of joints.** Arthritic joints may become fused when the articular cartilage is destroyed and periarticular and articular bone proliferation bridges the contiguous bones. Foot bone articulations may develop ankylosis because movement is minimal. In the early stages of DJD, pain and discomfort accompany movement of the joint (Fig. 20.24). When ankylosis is complete, no pain may be associated with the joint, but stiffness may alter the gait and wearing pattern of the slipper and toenails. An altered gait may predispose the foot to other conditions.

### Parasitic Diseases

Parasitic diseases of the foot are discussed in more detail in Chapter 12.

**Myiasis.** Many species of blowflies (bottle flies, family Calliphoridae) may deposit eggs in open wounds of the foot. The larvae feed on exudates and necrotic debris and usually do little damage, but the larvae are unsightly.

Screwworm flies are another matter. The New World screw worm *Chochliomia hominivorax* is currently absent in North America. The Old World screw worm is *Chrysomya bezziana*. Both have similar life cycles. The female fly deposits eggs at the margin of fresh wounds. Second instar larvae invade living tissue, and third instar larvae bury themselves in living tissue so only the posterior peritremes are visible. Severe destruction of tissue may accompany infestation.

**Microfilarial dermatitis.** Microfilarial dermatitis around the toenail bed and heels of Asian elephants has been ascribed to a *Stephanofilaria* sp. (indistinguishable from *S. assamensis*) in Asia.[8,63] See details in Chapter 12.

## PREVENTION OF FOOT PROBLEMS

Elephant foot care involves daily inspection of the feet (stiff-bristled brush and hoof pick), exercise, training, sound nutrition, sanitation, spending as much time as possible on dirt or grass, and periodic pedicures.[49] Some elephant managers advocate providing heated floors during cold weather, which may contribute to the comfort of the elephant and hasten drying. Others disagree. Alternatives to concrete floors include heavy rubber mats, straw, or wood pallets. Exercise is more easily accomplished in a free contact program. Elephants may be taken for walks or used in elephant rides. Rides are controversial but they do address the need for exercise. It takes more creativity to encourage exercise in voluntary contact behind a barrier.

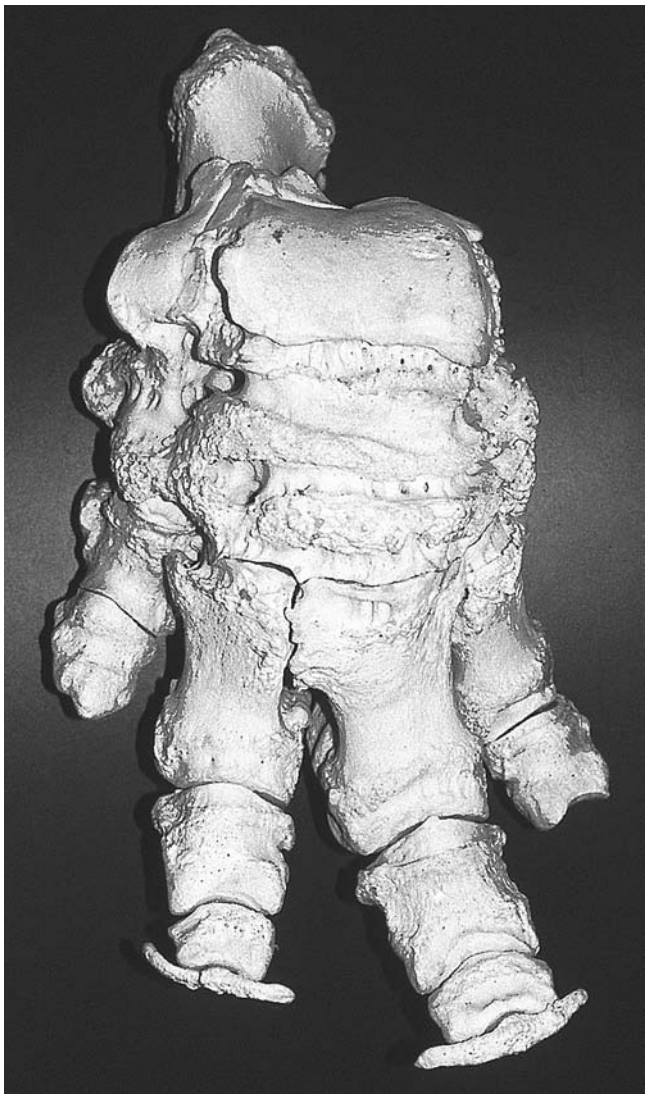

***Figure 20.24.*** *Degenerative joint disease and ankylosis of an elephant foot.*

### Nutrition

Energy intake must be correlated with body condition. Excessive weight is a detriment to foot health. Be aware of the caloric content of the diet. Free-choice hay and/or fruits and vegetables may be contraindicated for certain elephants (easy keepers). Grass hay is usually sufficient

except for juveniles and late-gestation pregnant or nursing females.[59]

Biotin (vitamin B) has been shown to be beneficial to equine hoof health.[48] No studies have been conducted on elephants, but vitamin and trace mineral supplements may be appropriate to minimize deficiencies. Essential trace minerals known to have a function in skin and nail health include zinc, selenium, and arsenic, all of which may also be toxic when used in excess. Metabolic bone disease may occur in calves.[11,36] See Chapter 6.

## CONCLUSIONS

The following conclusions can be drawn regarding foot disorders in elephants:

1. Prevention is the key to elephant foot health.
2. Training is basic to routine foot care and therapy.
3. Daily foot inspection should be routine.
4. Early detection and aggressive management are crucial to rapid healing of lesions.

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