

Osteomyelitis in the Diabetic Foot First and Second Ray Amputation

Surgical Indications and Considerations

Anatomical Considerations: Osteomyelitis is an infection which involves the bone marrow, surrounding cortical bone, and the periosteum. It results in delayed healing of wounds, more extensive tissue damage, an increased length of stay in the hospital, and higher mortality rates. In the diabetic/neuropathic foot, the most frequent location of a plantar ulcer is the head of metatarsal I, with the interphalangeal joint of the first toe and the head of metatarsal II occurring almost as frequently. Bacteria can also invade through interdigital cracks, fissures, paronychias, and ingrown toenails. The size of the ulcer does not indicate the extent of necrosis.

Osteomyelitis is likely if the ulcer is greater than two centimeters in diameter, greater than three millimeters deep, or probes to bone. Ray resections are more durable and functional than transmetatarsal amputations, and are especially indicated in the patient with diabetes, whose other foot is at risk. No more than two ray resections are recommended to preserve the maximum foot stability. The bases of the metatarsals should be preserved if possible, to avoid instability of the Lisfranc (tarsometatarsal) joint.

Pathogenesis: Ulcers in the neuropathic foot usually occur because of trauma, including pressure from weight bearing, poorly fitting shoes, burns, and puncture wounds, due to loss of protective sensation. Injuries incurred with trimming of toenails and calluses can precipitate infection. Combined with an impaired immune response, and poor perfusion, nutrition, and glycemic control, patients with diabetes are at high risk for pathogens to enter a wound and extend to the bone. Autonomic neuropathy contributes to decrease in skin hydration and formation of skin fissures, providing a portal for bacteria. The infection may cause the formation of avascular tissue, which forms an area for persistent infection. The local infection can lead to gangrene, necrotizing fasciitis, and sepsis. It is usually polymicrobial, with gram-positive cocci being the most common, reportedly 50-70%. Gram-negative bacilli are increasing, up to 50%.

Epidemiology: Approximately 25% (16 million) of Americans with diabetes will have foot problems. 90% will have no infection with early intervention. 15% will have amputations, 5% of which will be major amputations. 85% of lower extremity amputations are preceded by foot ulcers. 68% of diabetic ulcers lead to osteomyelitis, many of which are asymptomatic. Of the hospital admissions for diabetes, 20% are for osteomyelitis in the foot. Drug resistant organisms (MRSA, VRSA) have increased the incidence, with long-term sequelae and morbidity. Ray amputations are the second most common amputation of the foot, next to toe amputations.

Diagnosis

- Clinical suspicion
 - Chronic wound must have careful history and thorough physical exam – the wound may not have the normal signs and symptoms of infection
 - Patient can have: pain (rarely), edema, erythema, induration, tenderness, draining

sinus tract, venous insufficiency, impaired range of motion, loss of sensory perception

- Any exposed joint capsule or bone should be assessed for osteomyelitis
- “Sausage toe” with pain and swelling only is a clinical sign with sensitivity and specificity
- “Fetid foot” – foul smelling wound drainage probably anaerobic
- Any ulcer that probes to bone is 100% predictive as osteomyelitis
- Ulcer diameter greater than two centimeters: 94% predictive
- Ulcer inflammation: 77% predictive

➤ Lab tests

- Gold standard is aerobic, anaerobic, fungal, and Acid Fast Bacillus bone culture of biopsy under direct vision during surgery
- Percutaneous needle biopsy under ultrasound or radiologic guidance – culture multiple specimens
- Swab culture of the sinus tract usually is not accurate
- Blood cultures positive only 50-80% of cases, only in acute stages, rarely in adults
- WBC elevated only in early stages
- Erythrocyte sedimentation greater 70 mm/hour with noninflamed ulcer: 100% predictive
- Check for hyperglycemia – people with diabetes may have normal temperature and blood studies

➤ Imaging studies

- Plain films will show soft tissue swelling and bone erosion in about two weeks, with periosteal reaction about four weeks later
- Three phase bone scan, radionuclide skeletal imaging, is gold standard; wide availability, documented sensitivity; detects early stage of disease and identifies multiple areas; specificity is low
- MR is equally sensitive, more specific; T1 has decreased signal intensity of bone marrow, T2 is increased, as is STIR(short tau inversion recovery); MR has good differentiation from bone tumor and infarction; useful in planning surgery
- CT can be helpful
- Often pathologic fractures with people with diabetes with osteomyelitis, especially the distal first or proximal second toe phalanges, with no history of trauma.

➤ Differential diagnosis

- Charcot – requires clinical observations and lab tests
- Must have wound to allow bacteria to penetrate to infect the bone
- Recalcification is not present on radiograph
- RSD
- Simple fractures
- Diabetic osteopathy – no wound, pointed distal metatarsal “peppermint stick sign” on radiograph - no surgery needed; if only clinical findings, then need biopsy

Nonoperative Versus Operative Management: In the acute or initial stages of osteomyelitis in the diabetic foot, IV antibiotics are mandatory and it is precluded that coverage is in effect before any advanced wound management is initiated by the physical therapist. This plan often can be effective, at least in postponing surgical intervention. Irrigation and debridement with pulsatile lavage with suction (PLWS), sharp debridement, topical antimicrobials for short term (about two weeks) for surface bacteriostasis, advanced wound dressings (including living skin equivalents) to provide a moist wound healing environment, negative pressure wound therapy (NPWT), and off-loading are strategies for wound management. Infection control measures are of paramount importance, employing standard precautions, including hand washing and proper Personal Protective Equipment (PPE), especially with the spread of drug resistant organisms. Systemic hyperbaric oxygen therapy (HBO) has a lethal effect on strict anaerobic and some aerobic organisms, and has been shown to stimulate granulation, as has electrical stimulation (ES). They are somewhat controversial, as it is important not to close off any tracts. Whirlpool is contraindicated for neuropathic feet, as is any type of heat, to avoid burns, maceration, and further infection. Cytotoxic agents should not be used. Physical therapy also includes exercises for range of motion (ROM), strength, and circulation.

Glycemic control and optimization of nutritional status must be gained. If ischemia is present operative intervention is necessary for revascularization of the lower extremity to improve large vessel perfusion.

Systemic antibiotics, IV and oral, are necessary for six weeks to six months, until the wound cultures are negative. In acute osteomyelitis sequential, high dose IV antibiotics can decrease the role of surgery. Response can be evaluated by monitoring the C-reactive protein level, often decreasing the duration to three to four weeks. The choice of antibiotics is determined by specimen cultures or stains, obtained by aspiration, needle biopsy, or swab. Also taken into consideration is the age and health status of the patient, the site of the infection, local sensitivity patterns, systemic toxicity, drug allergies, and any previous antimicrobial therapy. Initial coverage is broad spectrum, with specific antibiotics when the organism(s) is identified. With fluoroquinolones, photosensitivity is produced, and the risk is present of tendinopathy, especially of the Achilles, with possible rupture.

Surgical Procedure: If osteomyelitis spreads to a joint, it is considered an orthopedic emergency. Articular cartilage can be damaged in just hours. Surgical debridement includes removing all overlying callous, sinus tracts, infected granulation tissue, dead tendon, exposed cartilage, bursal tissue, and all soft bone to bleeding cancellous and firm cortical bone. All purulent exudate should be drained, and the wound left open for delayed primary closure, to allow for inspection and further debridement if needed.

If osteomyelitis involves the entire toe, the ray should be resected: the digit plus the head and shaft of the corresponding metatarsal (MT). Removal of the first ray is devastating to both stance and gait, as an intact medial column is essential to proper forward progression. It is valuable to try to save most of the MT shaft, especially the proximal portion to minimize pronation abnormalities. If the entire MT has to be amputated and the tibialis anterior tendon is not damaged, it should be reattached to the medial cuneiform. Loss of the anterior tibialis will

result not only in pronation of the foot, but will transfer excessive pressure to the MT II head, which will lead to breakdown.

If the second toe is involved, it is wise to remove MT II at its proximal metaphysis along with the toe, to preserve cosmesis and function (avoid valgus). The distal toes should be filleted to create additional soft tissue for closure. The wound should be closed on the dorsum of the foot, preserving the plantar skin. Sutures should remain intact for three-four weeks due to delayed healing in patients with diabetes, due to impaired nutrition and oxygen delivery at the surgical site, plus tissue ischemia. The inflammatory phase of healing is limited due to abnormal phagocytosis, contributing to edema. Protein metabolism is also abnormal, impairing fibroblastic proliferation, collagen synthesis, and new capillary formation. Future split thickness skin grafts are often necessary for complete wound closure.

Preoperative Rehabilitation

- Physical therapy wound management: PLWS, sharp debridement, possible NPWT, advanced wound dressings
- Pressure ulcer prevention
- Off-loading, non-weight bearing (NWB) on affected lower extremity; wheel chair or walker, monitoring for carpal tunnel syndrome, 11% more likely with patients with diabetes. Crutches not advised due to neuropathy.
- Monitor and protect integumentary integrity of opposite lower extremity
- Education re: post surgery: gait, diabetic foot inspection, footwear/orthotics, opposite lower extremity inspection and protection, nutrition, glucose control, no smoking
- If no sepsis, ROM and strengthening exercises; watch for antibiotic reactions, including hypersensitivity; nausea, vomiting, diarrhea (may need to alter time of PT treatment)
- Ultraviolet (UV) sensitivity, with need to establish an accurate minimal erythema dose if utilizing UV radiation
- Social/family support
- Psychology consult

POSTOPERATIVE REHABILITATION

Note: There is a lack of evidence-based studies to support the rehabilitation interventions of patients with ray amputations, especially those with diabetes following surgery due to osteomyelitis. Research should and must be done with the explosion of new diagnoses of diabetes in the population.

Phase I: Weeks 1-4

Goals: Control edema

Accelerate wound healing process

Eliminate pressure
 Prevent contractures and loss of strength
 Eliminate infection
 Control pain

Intervention:

- Elevation of foot on one pillow if low ABI
- PLWS, sharp debridement, advanced wound dressings
- NWB with walker or wheelchair
- Suspend heel in bed or sitting; therapeutic positioning in bed
- Active, active assistive, and passive ROM exercises for adjacent joints
- Achilles tendon stretching; may require surgical lengthening in the future
- Rest, antibiotics, infection control measures with wound management
- Pain medications

Phase II: Weeks 4-8 (up to 27: wound closure)

Goals: Wound closure
 Continue to eliminate pressure
 Increase strength
 Eliminate infection

Intervention:

- PLWS, sharp debridement, NPWT/advanced wound dressings, ES, growth factors, skin substitutes
- NWB with walker, wheelchair, or total contact cast (TCC) if infection clears
- Avoid high intensity exercise to avoid increase in blood pressure, which could cause further damage to retinas and kidneys. Avoid putting head below the waist to prevent further retinal damage
- Antibiotics
- Infection control measures with wound management

Phase III: Weeks 8 (or at wound closure) - lifetime

Goals: Protect and accommodate remaining portion of foot
 Equalize weight bearing to protect remaining MT heads from increased pressure (as medial arch can collapse)
 Minimize drifting of remaining toes
 Improve gait
 Restore functional capacity

Intervention:

- Consult orthotist, pedorthist, shoemaker – patient should never take an unprotected step. Use adaptive and supportive footwear.
- Soft, moldable upper to protect and accommodate remaining foot
- Sandals for shower, night trips to bathroom
- Custom molded shoe or total contact insert with strong medial counter to support the medial arch
- Roller or rocker bottom shoe with flare and external extended steel shank or internal rigid carbon footplate to protect remaining MT heads and for improved gait by enhancing the loss of toe-off and adding stability to anteroposterior plane. High top shoes may be necessary to prevent the heel from slipping out of the heel counter
- Heel raise added to shoe to prevent dorsiflexion of the forefoot, with the same raise used on the contralateral shoe
- Provide shoe filler for amputated portion of foot, including toe fillers
- No high heels to avoid increased forefoot pressures
- Expanded toe boxes to accommodate claw toe deformities caused by intrinsic imbalance in remaining toes
- Exercises to strengthen remaining plantar flexors to increase power in push-off – insertions of plantar fascia and flexor hallucis are lost
- Gait training for ascending/descending stairs

Selected References:

Attinger C, Venturi M, Kim K, Ribiero C. Maximizing length and optimizing biomechanics in foot amputations by avoiding cookbook recipes for amputation. *Seminars in Vascular Surgery*. 2003; 16:44-66.

Eneroth M, Larsson J, Apelqvist J. Deep foot infections in patients with diabetes and foot ulcer: an entity with different characteristics, treatments, and prognosis. *Journal of Diabetes and Its Complications*. 1999; 13:254-263.

Karchmer AW, Gibbons GW. Foot infection in diabetes: evaluation and management. *Current Clinical Topics in Infectious Diseases*. 1994; 14:1-22.

Lipsky BA. Osteomyelitis of the foot in diabetic patients. *Clinical Infectious Diseases*. 1997; 25:1318-26.

Nehler MR, Whitehill TA, Bowers SO, Jones DN, et al. Intermediate-term outcome of primary digit amputations in patients with diabetes mellitus who have forefoot sepsis requiring hospitalization and presumed adequate circulatory status. *J Vasc Surg.* 1999; 30:509-17.

Paluska SA. Osteomyelitis. *Clinics in Family Practice.* 2004; 6:127-149.

Philbin TM, Leyes M, Sferra JJ, Donley BG. Orthotic and prosthetic devices in partial foot amputations. *Foot and Ankle Clinics.* 2001; 6:215-228.

Snyder RJ, Cohen MM, Sun C, Livingston J. Osteomyelitis in the diabetic patient: diagnosis and treatment. part 2: medical, surgical, and alternative treatments. *OstomyWound Management.* 2001; 47(3):24-43.