CE

Orthopaedic Trauma
Pilon Fractures

Pamela L. Horn ▼ Matthew C. Price ▼ Scott E. Van Aman

Pilon or plafond fractures occur in the distal portion of the tibia. These fractures are commonly the result of high-energy trauma and are associated with increased morbidity due to their complicated nature and location. Thorough assessment, including soft tissue involvement and immediate joint reduction, are the cornerstones of care prior to surgical treatment determination. This article will provide an overview of anatomy, mechanism of injury, physical assessment, presentation of fracture types, imaging studies, and treatments. Issues affecting surgical decision-making, factors affecting morbidity, complications, nursing implications, and rehabilitation will also be discussed.

Pilon or plafond fractures are the result of high-energy trauma due to rotational or axial-loading forces (Barei & Nork, 2008). These types of fractures can be very challenging to the orthopaedic surgeon because of the intra-articular nature, coexistent soft tissue injuries, and other body systems involved (Manca et al., 2002).

The term *pilon* is often used interchangeably with "plafond" when discussing these distal tibia fractures. The word *pilon*, which is derived from the French language, was introduced by Destot in 1911 (Barei & Nork, 2008). This refers to a pestle, which is a club-shaped tool for mashing or grinding substances in a mortar or using a large bar to stamp or pound vertically. A pilon fracture describes the motion of the talus acting like a hammer or pestle as it crashes into the tibial plafond. Destot described these fractures as "explosive injuries" (Sands et al., 1998) and subsequently, as noted in Orthopaedia Main (2007) and Barei (2010), they have also described these injuries as "explosion fractures."

Anatomy

Plafond, loosely termed, means ceiling or dome. The tibial plafond is the ceiling or dome over the talus (Barei, 2010; see Figure 1). This creates a smooth surface, allowing the talus to articulate with the distal tibia. While pilon and plafond are used interchangeably, one describes an action and the other an entity. The ankle joint is formed by the tibial plafond superiorly, the talus inferiorly, and the malleoli medially, laterally, and posteriorly (Michelson, 2003; see Figure 2). In the sagittal plane, the plafond is concave and in the coronal plane, it is convex. It is wider anteriorly for stability especially while bearing weight (Orthopaedia Main, 2007; see Figure 1).

Ligaments that support the distal tibia are the tibiofibular ligament, including the anterior, posterior, and transverse portions; the interosseous ligament; and the deltoid ligament that is divided into superficial and deep portions (Orthopaedia Main, 2007; see Figure 2).

Mechanism of Injury

Approximately 7%–10% of all tibia fractures present as pilon fractures (Egol, Koval, & Zuckerman, 2010) and comprise less than 1% of all lower extremity fractures (Sands et al., 1998). Most pilon fractures are a result of very high energy trauma such as a fall from a significant height, motor vehicle collisions, motorcycle accidents, and industrial mishaps (Barei, 2010; Egol et al., 2010). With the advent of improved life-saving automotive restraints, there has been a resultant increased incidence of axial load-type intra-articular distal tibia fractures that challenge orthopaedists and trauma surgeons (Barei & Nork, 2008).

Axial compression and other high-energy injuries cause the talus to be directed forcefully into the plafond impacting the articular surface to varying degrees. Plantar flexion primarily results in posterior plafond injuries, dorsiflexion usually results in damage to the anterior plafond, and a neutral position commonly results in anterior and posterior fracture fragments (Barei, 2010; Egol et al., 2010). Patients may present with nondisplaced intra-articular fractures, or there could be significant comminution extending into the metaphysis with intra-articular debris. Because of the mechanism of injury, the fibula is frequently fractured with comminution as well (Barei & Nork, 2008).

Physical Assessment

Because these fractures are caused by considerable force, the main priority for a patient with a pilon fracture is their ABCs (airway, breathing, and circulation). Secondary and

Pamela L. Horn, MS, CNP, RNFA, Director, Orthopedic Mid-Level Providers, Riverside Methodist Hospital, Columbus, OH.

Matthew C. Price, MSN, CNP, Orthopedic Nurse Practitioner, Riverside Methodist Hospital, Columbus, OH.

Scott E. Van Aman, MD, Foot and Ankle Orthopedic Surgeon, Ohio Orthopedic Center of Excellence, Columbus, OH.

The authors have disclosed that they have no financial interests to any commercial company related to this educational activity.

DOI: 10.1097/NOR.0b013e31822c5abc

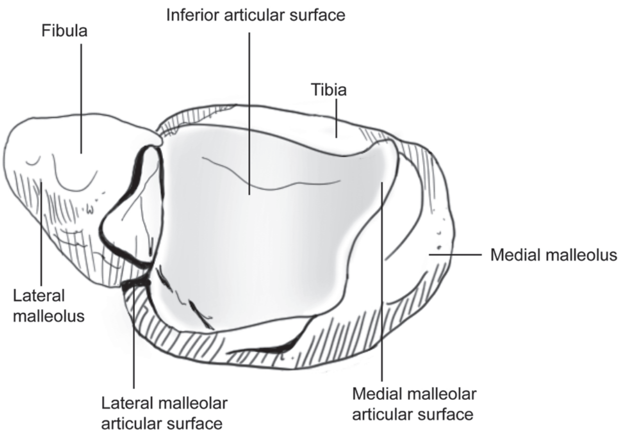

FIGURE 1. Tibial plafond (Picture reproduced by Dustin Horn).

tertiary surveys should be performed by trained trauma professionals. In several reports, between 27% and 51% of patients with tibial plafond fractures had other major system injuries (Barei, 2010; Egol et al., 2010). Obtaining a thorough history (when possible) gives the surgeon the information needed to determine the magnitude of the injury and to begin to formulate a surgical plan.

Examination of the ankle needs to be done in a logical and systematic fashion (Barei & Nork, 2008). One should note the degree of swelling, contusion severity, presence of abrasions or open wounds, and early blister formation. Fracture blisters can occur within hours or up to 2–3 days postinjury (Barei, 2010). Compartment syndrome should be ruled out during the initial examination using repeat serial examinations as well. To check the circulatory status of the foot, pedal pulses should be palpated or a Doppler ultrasound should be utilized. One should also note the temperature and color of the foot using the contralateral side, if able, for comparison (Barei & Nork, 2008). The dorsal and plantar aspects of the foot should be examined for sensation again using the unaffected foot as needed for baseline comparison. Particular attention should also be given to the ipsilateral extremity to evaluate for possible calcaneal, tibial plateau, hip, acetabular, or pelvic fractures, as well as evaluating the spine for vertebral fractures (Barei, 2010; Egol et al., 2010).

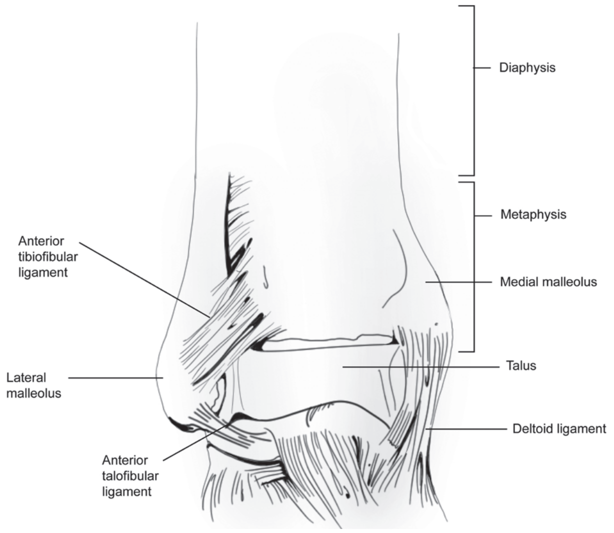

FIGURE 2. Ankle joint (Picture reproduced by Dustin Horn).

Fracture Types/Classification

In 1969, Drs. Ruedi and Allgower developed a classification system with regard to pilon fractures (Sands et al., 1998). The classification system consists of three types: type I, cleavage fracture with minimal displacement of the articular surface; type II, articular surface displacement that is significant without comminution; type III, comminution with impaction of the distal articular surface (Barei, 2010; Egol et al., 2010; see Figure 3). The AO/OTA (orthopaedic trauma association) classification system breaks it down even further. Type A fractures are extra-articular, type B fractures are partial articular, and type C fractures are total articular. Within each type are subdivisions based on the amount of comminution.

IMAGING

If the patient has a clinically stable appearing fracture, initial radiographs are obtained, which consist of an anterior-posterior view, a mortise view (the leg is internally rotated 15°–20°), and a lateral view (Barei & Nork, 2008; Egol et al., 2010; see Figures 4 and 5). Computed tomographic scanning is another important diagnostic tool. It helps to improve injury assessment and preoperative

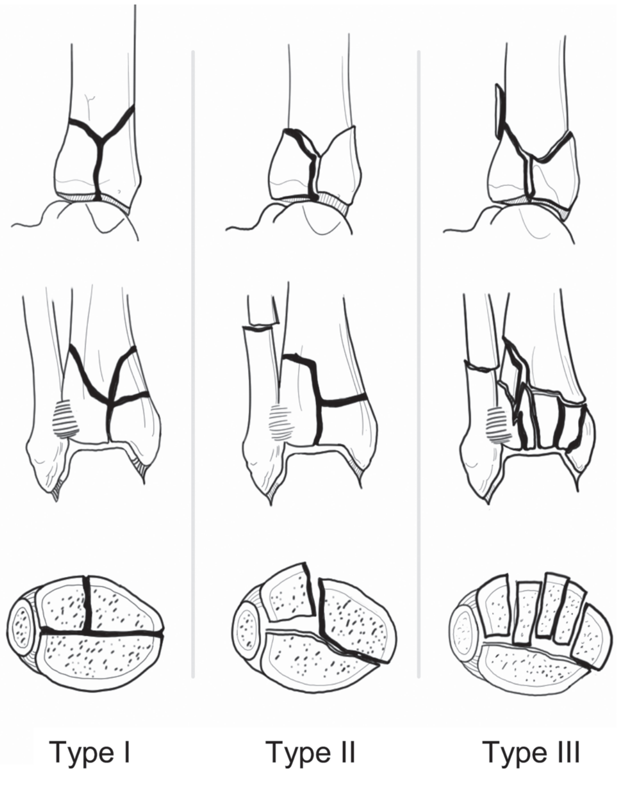

FIGURE 3. Reudi and allgower classification (Picture reproduced by Dustin Horn).

FIGURE 4. Right pilon fracture—AP view.

planning and is almost always obtained prior to surgery. Coronol and sagittal reconstruction, as well as contralateral views, are also helpful in surgical planning when possible (Egol et al., 2010).

TREATMENT(S)

During the initial examination and assessment of the patient's ankle, if there is an open fracture, dislocation, or extensive soft tissue damage, the No. 1 priority should be joint reduction and wound care, even before radiographs are taken. Urgent irrigation with sterile saline should be performed with removal of foreign debris and a sterile dressing should be applied. If there is extruded bone, a dislocation, or severe displacement, immediate reduction should be attempted to further reduce soft tissue injury; a splint may then be applied and radiographs taken. For open injuries, antibiotics are generally started intravenously as soon as possible (Barei & Nork, 2008; Egol et al., 2010).

Barei and Nork (2008) note that very few patients with pilon fractures are treated nonoperatively. Patients sustaining a Type I fracture with no displacement, comminution, or soft tissue damage may be candidates. These patients can be placed in a long leg cast for 6 weeks followed by a fracture boot with range of motion. The main disadvantage with this treatment is the inability to observe soft tissues and monitor swelling (Egol et al., 2010). Another group that may be treated nonoperatively includes those with preexisting comorbidities or acute, severe, multisystem injuries where surgery may not be an option.

For most patients with pilon fractures, surgical fixation of some sort is achieved as soon as possible; more emergently in those with open fractures (the author feels 8 hr or less is optimal). The main principles of surgical care consist of restoring anatomic fibular length; anatomically restoring the distal tibial articular surface; using bone graft, if needed, for metaphyseal defects; and plating to stabilize the medial buttress (Barei & Nork, 2008; Sands et al., 1998). There is flexibility now with regard to plating and delaying definitive fixation. In the last two decades, more patients with pilon fractures, particularly Type III fractures, are initially treated with spanning external fixation with or without fibular fracture stabilization, and with or without percutaneous internal fixation (see Figure 6). Any open reduction and internal distal tibia fixation is delayed

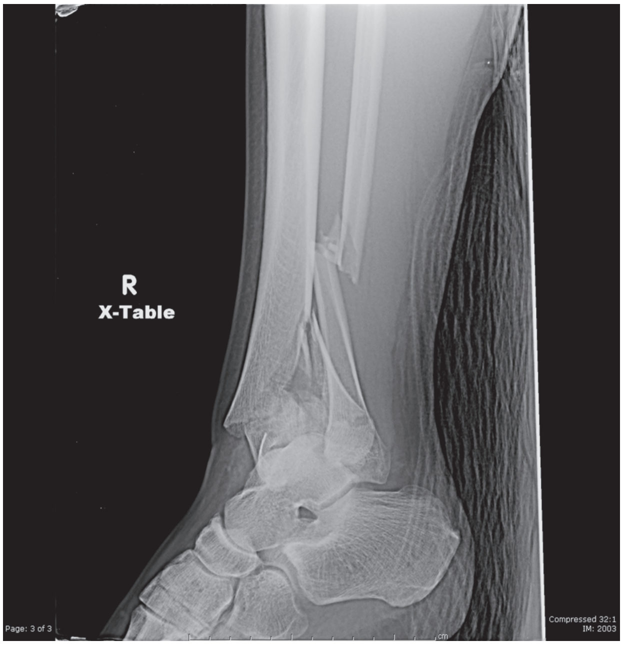

FIGURE 5. Right pilon fracture—lateral view.

FIGURE 6. Patient in spanning provisional external fixator.

7–21 days, given the amount of soft tissue damage, fracture blisters, and other patient issues (Barei & Nork, 2008; Manca et al., 2002). Blauth, Bastian, Krettek, Knop, and Evans (2001) also prefer this two-step procedure in patients with severe tibial plafond fractures and extensive soft tissue damage. Gardner, Mehta, Barei, and Nork (2008) have also noted fewer complications, using external fixation initially followed by staged (1–3 weeks), internal plating and grafting when patients present with Type III pilon fractures and bone loss.

There are many internal surgical approaches to plafond fracture fixation: anterolateral, anteromedial, posterolateral, and posteromedial (Barei & Nork, 2008; Bhattacharyya, Crichlow, Gobezie, Kim, & Vrahas, 2006; Mehta, Gardner, Barei, Benirschke, & Nork, 2011). Ultimately, each patient should be treated on a case-by-case basis with regard to their fracture, soft tissue involvement, and comorbidities (see Figure 7). One point to make is that some patients' fractures are best treated with definitive external fixation only.

Fracture-Related Morbidity Issues

There are many issues related to adverse outcomes when dealing with patients with pilon fractures. The force necessary to produce the fracture, soft tissue injuries, swelling, fracture blisters, the patient's age, and general health are all contributing factors. One of the more important factors is the amount of energy involved during the fracture occurrence. Typically, higher energy increases morbidity and the potential for complications. Intra-articular ankle fractures often lead to osteoarthritis, limited joint function, and chronic pain (Anderson et al., 2008).

Figure 7. Three weeks later: Ex-fix removed and definitive plating applied.

Open fractures and the degree of comminution are also important considerations when discussing preoperative planning and patient care (Sands et al., 1998). Patients with open fractures historically have a worse prognosis with regard to rates of infection; therefore, these patients need immediate intervention and broad spectrum antibiotics as previously discussed. Thodarson (2000) states that the incidence of wound complications, including deep infections, may be decreased by delaying surgery 5–14 days to allow for posttraumatic swelling to subside and by limiting the amount of internal fixation in general when there are no open wounds. This approach seems to be widely accepted in the orthopaedic community (Barei & Nork, 2008; Manca et al., 2002; Marsh, Weigel, & Dirschl, 2003.

The degree of comminution directly correlates with loss of ankle function secondary to pilon fractures. Pollak, McCarthy, Bess, Agel, and Swiontkowski (2003) state that patients who sustain these fractures can have persistent, devastating consequences to their health and well-being. Ankle fusion may be the only treatment of choice when patients are left with symptomatic osteoarthritis and chronic pain (Thodarson, 2004).

Fracture blisters are another issue relating to pilon fracture morbidity. According to Thodarson (2000), these blisters develop as a result of soft-tissue injury and rapid swelling. Two types of fracture blisters have been identified: clear-fluid–filled blisters and blood-filled blisters. Histologically, blood-filled blisters represent a more significant injury with higher reports of infection when surgical incisions have been made through them. The blisters contain sterile transudates, so it is widely accepted that it is best to leave the blisters intact whenever possible or wait until they have subsided. If a blister does rupture, it should be unroofed and covered with a nonadherent sterile dressing (Thodarson, 2000; see Figure 8).

Age and general health are two final concerns when patients present with pilon fractures. Older individuals may have degenerative changes, or osteopenia/osteoporosis, making surgical decision-making more difficult (Michelson, 2003). A patient's overall health can also directly impact patient care. Diabetic patients are especially challenging to treat because of their propensity for postsurgical soft tissue infection and potential skin breakdown with compressive dressings or splints (Michelson, 2003). In addition, patients who have smoked for an extensive time, those on anticoagulants, those who are immunosuppressed, and those with peripheral arterial disease are also high-risk individuals who need close monitoring after surgery.

Possible Complications

Following internal and/or external fixation, patients are followed closely in the hospital and in the outpatient setting to observe for complications related to fracture treatment. Most patients are placed in a well-padded splint postoperatively. The incision is examined within a week to assess for signs/symptoms of cellulitis or incisional infection (Thodarson, 2000). Superficial skin necrosis can usually be treated with local wound care. Early mild cellulitis can be treated with oral antibiotics in the appropriate patient population unless it does not respond and then antibiotics should be used intravenously (Barei & Nork, 2008). Sutures are generally removed 2–3 weeks postoperatively as long as there is no indication of wound dehiscence. Once the patient is home, careful observation of all wounds should be maintained by the patient or caregiver to monitor for signs/symptoms of infection. Follow-up radiographs may be needed for years to observe for nonunion or malunion of the fracture, to detect any possible hardware failure or need for delayed bone grafting, and to observe for arthritis that could necessitate the need for an arthrodesis (ankle fusion; Thodarson, 2000).

Nursing Implications

Patient care should be holistic with consideration of each body system to ensure optimal outcomes. One of these nursing measures is pulmonary toilet to prevent atelectasis. Incentive spirometry should be initiated as soon as possible, particularly with patients who smoke or are at risk for pulmonary complications such as asthma or chronic obstructive pulmonary disease. Using this in the upright position is optimal, and 10 times every hour is recommended.

Elastic stockings and calf pumps are used immediately postoperatively to prevent deep vein thrombosis (DVT) and to decrease edema. Swelling in the affected limb can persist for months; elastic stockings can help dependency-associated swelling. Another consideration in preventing DVT is keeping patients hydrated with oral and/or intravenous fluids. Also, depending on the patient's ambulatory status, age, and health, aspirin or lovenox may be warranted for several weeks for DVT and pulmonary embolism prevention.

Patients with lower extremity fractures can be at high risk for developing compartment syndrome. Compartment syndrome develops when one or more of the four compartments in the lower extremity develop an increase in pressure due to internal forces such as edema or external forces such as splinting. If the pressure increases too much without relief, muscle, vessel, and nerve cells die. This can, in turn, lead to motor function impairment, loss of limb, or even death. Vigilant monitoring of motor and sensory function includes hourly checks of patients at high risk such as those with severe swelling and crush injuries. Compartment syndrome can occur within 6 hr; therefore, any worsening or change in symptoms may indicate a need for an emergent fasciotomy. Some patients may complain of numbness and tingling initially, but no other symptoms. If this changes or worsens, and other symptoms are present, an immediate practitioner examination is warranted. Ask the patient to flex and extend their toes and encourage slight movements every hour. Examine the patient with gentle passive flexion and extension of the toes. If this elicits an extreme reaction, the patient could be at high risk. Many times, patients with compartment syndrome develop swelling in the forefoot and toes with a pale waxy skin color. If this should develop with pain with passive motion, inability to actively move the toes, and altered or decreased sensation, this patient is also at high risk. In addition, if a patient develops a dusky or bluish color to his or her toes, this should alarm the nurse. To prevent compartment syndrome, always have the affected limb elevated at heart level, encourage them to wiggle their toes often, ice the ankle off and on, and keep them well-hydrated. If they develop compartment syndrome, the only treatment is a fasciotomy.

Figure 8. Example of fracture blisters.

In external fixation cases, meticulous pin care is usually warranted to prevent pin track infection or, worse, osteomyelitis (Thodarson, 2000). In general, the type and frequency of pin care are typically directed by each individual surgeon. The author uses silver nitrate–impregnated sponge around the pins in the operating room and has the patient start half-strength hydrogen peroxide pin care at the first follow-up, which is generally in a week. Holmes and Brown (2005) conducted a literature review and from that came evidence-based pin site care recommendations. First, pins located in areas with considerable soft tissue may be at higher risk for infection and should be observed closely. Second, daily cleansing 48–72 hr after surgery should be instituted at sites with stable bone–pin interfaces. Third, chlorhexidine 2 mg/ml may be the best solution for effective cleansing. Fourth, patients and caregivers should be taught pin site care prior to discharge and be able to demonstrate proper technique before going home. The patient and their families should be educated on signs of pin site or pin track infection such as redness or worsening redness, exudates or purulence, foul odor, pain, and/or an elevation in temperature.

Hydration and stool softeners should be instituted early, depending on the patient's health, to prevent constipation associated with decreased activity and narcotic use, which can slow colonic activity. Constipation can lead to severe morbidity that could include abdominal pain, bloating, or an ileus that may prolong the hospital stay.

Any fracture can cause considerable pain. Pain can result in a multisystem sequela of symptoms, such as an elevation in pulse and blood pressure, increased respiratory effort, decreased appetite, and mental distraction. It is imperative to attempt reduction of pain with opioids initially, initiate ice and elevation, and use distraction measures to lessen the stress caused by pain. Many facilities use patient-controlled analgesia pumps, which allow the patient to manage the frequency of pain medication doses. This is generally efficient and gives the patient a sense of control as well.

Lastly, psychosocial issues are common with these types of injuries. Loss of work, interrupted family life, financial strain, and depression are some of the issues to be considered. Assistance from financial support, social services, and counseling should be initiated early as needed.

Rehabilitation

Posttraumatic stiffness following a pilon fracture is a common occurrence. As previously mentioned, fractures with greater degrees of comminution tend to have poorer outcomes with increased stiffness. This stiffness is related to the degree of articular destruction and periarticular soft tissue injury. The duration of immobilization also plays a large part in postoperative stiffness (Thodarson, 2000). Physical therapy initiated early involving active, active-assisted, and passive range of motion will help the patient regain motion sooner. Weight bearing is generally delayed for approximately 12 weeks. The patients may then begin partial weight bearing with an assistive device (Barei & Nork, 2008). If all attempts at regaining motion and diminishing pain have failed over time, a discussion may be held to decide if an ankle fusion, with or without bone grafting, would be best for a patient's overall health and well-being (Thodarson, 2004). Amputation may become a final consideration if a patient's overall health, quality of life, and other comorbidities prevent proper healing or restoration of function.

Summary

Pilon fractures are not hard to describe but can be very difficult to treat, often involving a lengthy, sometimes painful, recovery time. The early important factors to note are the degree of articular involvement; the amount of comminution; and the amount and manner of soft tissue involvement. These factors will determine the surgeon's decision making and type of treatment. Operative care involves protecting the skin, while reducing the fracture and aligning the joint surface. Surgery is more likely to involve external fixation with postponement of internal fixation for 1–3 weeks. Postoperative care should be vigilant and comprehensive to ensure that patients do not develop any adverse outcomes. Education regarding home care should be complete and easy to understand so that there are no misunderstandings that might delay treatment if complications should arise. Early motion and physical therapy should be initiated to prevent postoperative stiffness. Patients should be educated from the beginning that these fractures can be difficult to treat and the final outcomes may not always be optimal. With careful preoperative planning and excellent care, these patients may return to a good quality of life.

References

Anderson, D., Mosqueda, T., Thomas, T., Hermanson, E., Brown, T., & Marsh, L. (2008). Quantifying tibial plafond fracture severity: Absorbed energy and fragment displacement agree with clinical rank ordering. *Journal of Orthopaedic Research, 26*(8), 1046–1052.

Barei, D. (2010). Pilon fractures. In R. Bucholz, J. Heckman, & C. Court-Brown (Eds.), *Rockwood and Green's fractures in adults* (pp. 1928-1974). Philadelphia: Lippincott, Williams & Wilkins.

Barei, D., & Nork, S. (2008). Fractures of the tibial plafond. *Foot and Ankle Clinics of North America, 13*, 571–591.

Bhattacharyya, T., Crichlow, R., Gobezie, R., Kim, E., & Vrahas, M. (2006). Complications associated with the posterolateral approach for pilon fractures. *Journal of Orthopaedic Trauma, 20*(2), 104–107.

Blauth, M., Bastian, L., Krettek, C., Knop, C., & Evans, S. (2001). Surgical option for the treatment of severe tibial pilon fractures: A study of three techniques. *Journal of Orthopaedic Trauma, 15*(3), 153–160.

Egol, K., Koval., & Zuckerman, J. (Eds.). (2010). *Handbook of fractures*. Philadelphia: Lippincott, Williams & Wilkins.

Gardner, M., Mehta, S., Barei, D., & Nork, S. (2008). Treatment protocol for open AO/OTA type C3 pilon fractures with segmental bone loss. *Journal of Orthopaedic Trauma, 22*(7), 451–457.

Holmes, S., & Brown, S. (2005). Skeletal pin site care. National Association of Orthopaedic Nurses guidelines for orthopaedic nursing. *Orthopaedic Nursing, 24*(2), 99–107.

Manca, M., Marchetti, S., Restuccia, G., Faldini, A., Faldini, C., & Giannini, S. (2002). Combined percutaneous internal and external fixation of type-C tibial plafond fractures. *The Journal of Bone and Joint Surgery, 84*, 109–115.

Marsh, J., Weigel, D., & Dirschl, D. (2003). Tibial plafond fractures. *The Journal of Bone and Joint Surgery, 85*, 287–295.

Mehta, S., Gardner, M., Barei, D., Benirschke, S., & Nork, S. (2011). Reduction strategies through the anterolateral exposure for fixation of type B and C pilon fractures. *Journal of Orthopaedic Trauma, 25*(2), 116–122.

Michelson, J. (2003). Ankle fractures resulting from rotational injuries. *Journal of the American Academy of Orthopaedic Surgeons, 11*(6), 403–412.

Orthopaedia Main. (2007). *Orthopaedia-collaborative orthopaedic knowledgebase*. Retrieved February 17, 2011, from http://www.orthopaedia.com/x/FYEe

Pollak, A., McCarthy, M., Bess, R., Agel, J., & Swiontkowski, M. (2003). Outcomes after treatment of high-energy tibial plafond fractures. *The Journal of Bone and Joint Surgery, 85*(10), 1893–1900.

Sands, A., Grujic, L., Byck, D., Agel, J., Benirschke, S., & Swiontkowski, M. (1998). Clinical and functional outcomes of internal fixation and displaced pilon fractures. *Clinical Orthopaedics and Related Research, 347*, 131–137.

Thodarson, D. (2000). Complications after treatment of tibial pilon fractures: Prevention and management strategies. *Journal of the American Academy of Orthopaedic Surgeons, 8*(4), 253–265.

Thodarson, D. (2004). Fusion in posttraumatic foot and ankle reconstruction. *Journal of the American Academy of Orthopaedic Surgeons, 12*(5), 322–333.