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Pilon Fractures: A Review and Update

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Abstract: Pilon fractures are complex injuries due to many factors. The distal tibia lacks any muscle origin which makes it vulnerable to comminuted fractures. The soft tissue coverage is minimal at this level which leads to a higher propensity for open injuries. Conservative care is rarely indicated. Surgical planning must include advanced imaging to define the fracture pattern. Staging the injury to allow for optimization of the soft tissue envelop through the use of external fixation has many advantages compared to early open reduction internal fixation. The die punch fragment lacks any ligamentous attachments and possess a difficult task for anatomic reduction. The viability of the soft tissue, the amount of comminution, as well as the impaction force and rotation all must be considered for proper surgical planning.

Key words: pilon fracture; tibial plafond; die punch; constant fragment

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Pilon fractures are defined as intra-articular fractures of the distal tibia with extension into the ankle joint. The anatomic name for the tibial pilon, also known as the tibial plafond, was given for the resemblance to a pestle, an ancient tool used for grinding substances into a mortar. Fractures of the tibial plafond comprise 1% of lower extremity fractures and 7-10% of all tibia fractures [1,2,3,4]. These injuries can vary greatly in severity, as either closed or open fractures, with the patient's soft tissue envelop as the rate limiting component of the seriousness. Epidemiologically, males between the ages of 30-40 years-old typically present with this injury [2,3].

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The plafond exhibits a concave orientation in a sagittal and coronary direction and composes the majority of the proximal ankle joint articulation with the talus. The articular surface ranges from 8-10 cm and is adjoined by dense metaphyseal bone. Through the ligamentous attachments of the syndesmosis, the fibula is retained within the incisura to the tibia forming the proximal borders of the ankle mortise. The anterior inferior tibiofibular ligament, originating from the Chaput tubercle of the anterolateral tibia, inserts at the Wagstaffe tubercle of the distal fibula. This provides a reference needed for complex anatomical reconstructions [4,5,6].

The distal tibia possesses inherent vulnerability to comminuted fractures, due to the lack of muscular origin [7]. There is minimal soft tissue between the bone and dermal layer. This predisposes this type of injury to a higher propensity of open fracture. Also to be considered is the sole blood supply to the anterior medial subcutaneous side of the leg by the anterior tibial artery [7].

The mechanism of injury depends on the alignment of the foot within the ankle mortise at the time of injury. With the foot in dorsiflexion, a direct force will be transmitted through the anterior tibia. Conversely, a direct force on a plantarflexed foot will cause damage to the posterior tibia. When force is applied to a neutral foot the fracture can be anterior, posterior, or in combination. Typical axial compression of the tibial metaphyseal bone results in a comminuted shatter-type injury. If a torsional force with rotation is generated, the fibula may fracture in a transverse or oblique pattern. It is important to note the soft tissue is always damaged to some degree in these injuries, due to the inherent anatomy [7,8].

The amount of energy greatly affects the degree of articular damage with these injuries. Kinetic energy is equal to one half the mass times velocity squared ($KE=1/2MV^2$). Low impact injuries are comprised of rotational or torsion injuries, short falls, or sports injuries. High impact injuries include falls from a great height or motor vehicle accidents. These injuries typically see axial loading with the talus driven into the distal tibia. This force causes the distal articular surface to implode, which impacts the adjacent metaphyseal bone. The articular surface is most affected by the force, along with the position of the foot at the moment of impact [7].

These types of fractures result in constant fragments that are grossly maintained despite anatomic and injury mechanism variances. Advanced imaging, such as the axial view on computed tomography (CT), provides the best visualization for the extent of the osseous damage [9,10]. CT scans show details that are missed with radiographs. Surgical planning depends on accurate assessment of fracture pattern, amount of fragmentation, rotation, and articular impaction. Tornetta et al. found that CT scans changed the operative plan based on plain radiographs in 64% of the surgical cases [9]. The Chaput's fragment originates at the anterior lateral aspect of the tibia and can serve as a landmark for fibular length. The medial and posterior Volkmann fragments must be reduced to piece together the articular surface. The die punch fragment is located centrally and prevents reduction as well as true articular realignment. Topliss et al. found that the die punch fragment lacks any soft-tissue attachments and is not reduced by ligamentotaxis [8]. This fragment must be addressed via direct visualization to ensure restoration of the articular surface [7,8]. These fragments vary in size depending on the amount of comminution present.

Clinical Exam

The initial exam is essential to completely assess the full extent of the injury. Due to potential complications, pilon fractures should be considered soft tissue injuries that involve a fractured bone. The determination of open or closed injuries will dictate surgical timing. Traction and ligamentotaxis may reduce the potential for skin tenting necrosis as well as provide partial restoration of some anatomic alignment. CT scans should be performed post reduction to better assess fragment position and comminution [9,10].

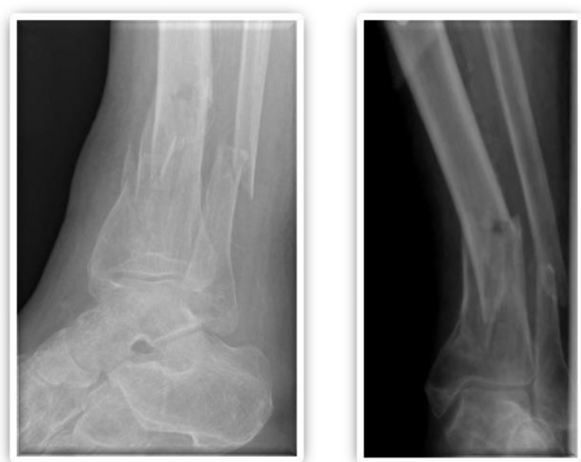

Figure 1: 65 year-old female sustain a low impact fall on uneven ground and fracture the distal tibia with extension to the joint as well as the distal fibula. The foot was laterally displaced in relationship to the proximal leg. CT scans show medial comminution and intra-articular fragmentation. The patient was placed in a Delta frame for 2 weeks until the edema was reduced and the soft tissue was optimal for ORIF.

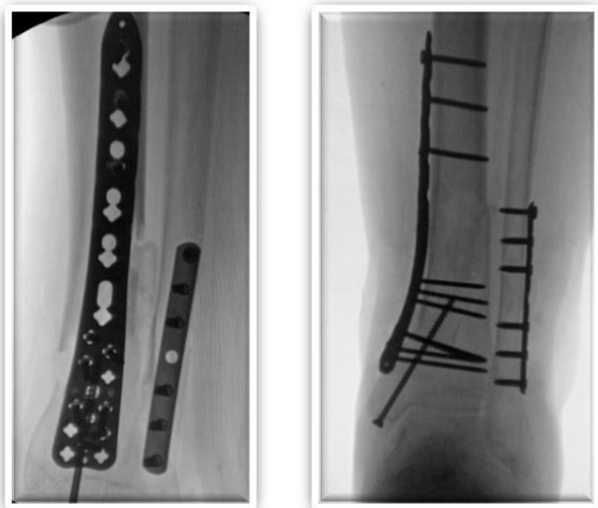

Figure 2: The fibula was reduced and anatomic length was restored by 1/3rd tubular plate. The medial comminution was addressed with a buttress plate place in MIPO technique with the screws inserted percutaneously.

McFerran et al. found a complication rate associated with early open reduction internal fixation (ORIF) in 34 of 35 patients. These patients developed either wound complication, deep infection, or both [11]. Several associated injuries can be present, due to the absorbed energy of these fractures. A valgus torsion resulted in the metaphyseal fracture of the fibula in 75-80% of patients [4,7,11]. Calcaneal, tibial plateau, pelvic, and vertebral fractures may also occur concomitantly [11,12,13]. Spinal films to evaluate the cervical and lumbar segments are recommended. Compartment syndrome must be considered with closed pilon fractures, as well as concomitant calcaneal fractures.

Discussion

Conservative treatment is rarely considered the best option. Only in essentially non-displaced or severely debilitated patients should cast immobilization be the final treatment. Closed reduction as a sole treatment demonstrates very poor results [4,14,20]. The amount of comminution does not allow a stable fragment platform for reduction and will result in some loss of anatomical alignment. This has the potential to risk further damage to the soft tissue if the fragments displace further [14,20].

Unlike purely ligamentous injuries with a high correlation of post traumatic arthritis, primary arthrodesis is an impulsive option. An ankle fusion should be reserved for patients that have a high degree of articular damage, but even then it is impossible to predict the onset of arthritis. Zelle et al. advocated arthrodesis if greater than 50% of the impaction area was located at the tibial plafond. Over a 15-year period, only 20 patients underwent a fusion within 30 days following a pilon fracture. Patient satisfaction compared unfavorably to ORIF in aspects of physical, emotional, and bodily pain [15].

External fixation (ex-fix) poses an excellent option as an adjunctive treatment by limiting the soft tissue insult, while still stabilizing the fracture. Ex-fix restores length and allows access to perform any necessary wound care. Hybrid variations permit ankle joint range of motion to lessen stiffness [16]. Vidyadhara and Rao report that a ring fixator preserves blood supply, while compressing small fragments at the same time [17]. Ex-fix can serve as definitive treatment for large articular fragments. Open fractures with extensive soft tissue damage pose a greater risk for complication with open surgery [18]. Ex-fix bears less risk for deep infection. In cases of severe metaphyseal comminution, ex-fix may prevent further crushing of smaller fragments [19]. However; Thordarson found a high incidence of metaphyseal nonunion [20]. Some drawbacks to ex-fix are a longer required consolidation period, with a likely 4 months in a fixator. Ex-fix offers less than anatomic reduction and the die punch fragment is not addressed [8,18,19]. The inability to reduce the die punch fragment prevents ex-fix from being the true definitive treatment in comminuted fractures. Wyrsch et al. found in a prospective randomized controlled trial that ex-fix clinical outcomes were similar to ORIF with significantly fewer complications [21]. Watson et al. found better patient satisfaction results with ex-fix greater than ORIF after 5 years post-injury [22].

Surgical intervention is indicated for any cases of articular displacement measuring greater than 2 mm, as well as an unacceptable axial alignment. Immediate ORIF is only permissible when soft tissue is in good to excellent condition [22]. Surgical planning must include an honest soft tissue assessment, evaluation of the articular surface, and the degree of comminution that may compromise the maintenance of ankle position to the leg. The surgeon must adequately manage any bone loss, address any metaphyseal defect, restore the length of the fibula, and reduce the tibial articular surface. The ultimate position of the ankle in relation to the leg can dictate the potential for post-traumatic arthritis [23].

Incision planning must consider the best access to large fragments. Skin bridges should be limited to 6-7 cm intervals [24,25]. Extensive incisions have a potential "Pandora's Box" effect to increase the risk of complications. Recognition of potential soft tissue and neurovascular bundle interposition is required when planning the incision placement. Herscovici et al. advocates an anterolateral approach to better access the distal anterolateral (Chaput) fracture fragments. This approach facilitates direct reduction of the articular surface and provides greater soft tissue coverage over implants, as compared with the traditional anteromedial approach. Advantages to adopting a no touch retraction technique utilizing Kirschner wires, as opposed to over aggressive manual retraction, have also been shown [26].

Traditionally a two stage approach has been supported as the preferred surgical method. Helfet described the first stage to include temporary external fixation of the tibia and ORIF of the fibula to restore length and rotation. The second stage consisted of definitive fixation once the soft tissue was optimized [27]. The literature suggests waiting at least 10 days, until the skin displays a positive wrinkle test and any blisters have re-epithelialized [27,28].

A new approach that has many advantages is denoted as minimally invasive percutaneous plating osteosynthesis (MIPO). Fracture variants with extensive metaphyseal-diaphyseal comminution that are not amenable to direct reduction without extensive exposure are excellent candidates for MIPO consideration [25]. This technique offers the benefit of reduced wound healing complications and improved rates of union, due to the lack of periosteal stripping. The presence of callous formation from secondary bone healing is common [25,27]. Vallier et al. used intramedulary nails for fixation, with complication and union rates comparable with plating of fractures that possessed only mild impaction [29]

Regardless of fixation, medial buttress plating must be employed to lessen the propensity of varus collapse [14,29]. Preservation of the periosteal attachment of the fragments maintains the blood supply and increases the likelihood of healing [14]. The order of fixation varies, as determined by fracture pattern. Some experts believe initial fixation of the fibula will provide a roadmap for the tibial reconstruction [30,31]. However, the fibular fixation has the potential to create a tether through the syndesmosis, which may impair tibial fracture reduction. The Chaput's fragment attached by the anterior inferior tibiofibular ligament may serve as a guide for tibial length. Retraction of the medial malleolus permits reduction of the posterior malleolar fracture and provides articular surface visualization [30,31].

Complications are expected with increasing severity of the injury. Deep infections are seen up to 55%, while delayed or non-unions are found in up to 22% [24]. Long-term follow up studies show post-traumatic arthritis in 13% to 54% [11,14,24]. It is prudent to discuss the likely need for ankle arthrodesis as part of the expected postoperative course. Most cases dictate a non-weight bearing period of 12 weeks, with the consequence of post-traumatic stiffness being quite common. Crist et al. report it easier to manage the complications of closed management than those of an ill-advised ORIF [32]. Midfoot loading is increased due to ankle joint range or motion restriction. Megas et al. reported the nonunion rate in distal tibial fractures to be the highest of all long bone fractures. They found most occurred at the metaphyseal-diaphyseal junction and were a result of traumatic de-vascularization from soft tissue stripping. The study showed inadequate fragment stabilization, which often occur medially and caused varus malalignment [33]. Negative Pressure Wound Therapy (NPWT) is an effective adjunct to decrease wound complication and infection rate. Incisional NPWT increase microvascular flow to skin and control edema postoperatively [34].

In conclusion, results following the management of pilon fractures have been closely tied to initial injury severity, mechanism of injury, amount of displacement, and force acting upon the anatomic structures. At present, no single surgical treatment method has demonstrated superiority. Pilon fractures should be considered significant soft tissue injuries, which also involve fractured bone.

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