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Functional Outcome of Delayed Anterolateral Plating for Tibial Pilon Fractures

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ABSTRACT

BACKGROUND & OBJECTIVES: The Management of Tibial pilon fractures have always been perplexing. Our study was planned to evaluate functional outcome of delayed anterolateral plating for tibial pilon fractures by assessing the range of motion of ankle along with pain and affection in the activities of daily living.

MATERIALS AND METHODS: A prospective observational study was done for 45 patients with tibial pilon fracture, for whom delayed anterolateral plating was done in Orthopaedics department of Government medical college, Thiruvananthapuram. The study was conducted at 6 months of follow up after surgery is done. Data collected using a structured proforma. The evaluation of results is based on scoring system given by kaikkonen ankle score

RESULTS: Functional outcome was assessed at 6th month follow up using kaikkonen ankle score. The mean age of the patients was 38.53(19-72) and among them 52.78% had right side affected. 37.78% had excellent functional outcome and 51.11% had good functional outcome at the end of 6 months. Best functional outcome was obtained in Ruedi Allgower type 1 fractures. Wound related infections were noted in 6.7% cases who had significantly poor functional outcome

CONCLUSION: Hence delayed anterolateral plating greatly improves the functional outcome in patients with tibial pilon fractures and allows for earlier mobilization and prevents complications like malunion.

KEYWORDS: kaikkonen ankle score; Ruedi Allgower classification

INTRODUCTION

One of the biggest treatment issues facing orthopedic traumatologists is still distal tibial fractures. This is caused by a number of factors, but none of them may be as challenging as the associated soft tissue injury that is often present. Pilon fractures are ankle fractures that affect the weight-bearing distal tibial articular surface; they were first reported by the French radiologist Destot in 1911 [1] The word "pilon," which comes from the French word for "pestle," describes a club-shaped instrument used for crushing or grinding materials in a mortar or a big bar that is moved vertically to stamp or pound. A comparable fracture would later be referred to by Bonin as a "plafond" fracture. Plafond, which translates to "ceiling" in French, compares the weight-bearing surface of the distal tibial articular to the ankle joint's ceiling. [2] A pilon fracture is a descriptive term that implies that the talus works as a hammer or pestle that impacts and injures the tibial plafond, despite the term being used interchangeably with "plafond." When Ruedi released a seminal work on the subject in 1968, it clarified several important features of these poorly known injuries by describing the fracture, outlining its treatment guidelines, and providing a categorization system. [3]Over the past years there has been a shift in approach to management of plafond fractures giving due emphasis to the soft tissue cover. Poor functional outcome and high rate of post operative complications mainly attributed to the practice of meticulous osseous fixation and giving less priority to the soft tissue cover. There is controversy over the best way to treat these difficult injuries, despite the fact that numerous therapeutic modalities and regimens have been documented. In a comparable way, there are still no long-term outcome data from randomized comparative treatment approaches. Hence the surgeon should find a balance between the insult that the soft tissue can tolerate versus the reduction attained prior to fixation especially when it comes to articular surface. Despite extensive documentation regarding the severity of these injuries, the intricacies of various treatment approaches, and the constraints of management, patients sustaining these injuries still fail to experience satisfactory long-term outcomes from their therapy. When Ruedi treated tibial plafond injuries with rapid fixation, as he first described in 1968, the results were good and long- lasting with minimal problems. The persistence of the first outcomes was shown in follow-up research published in 1973, which evaluated 54 of the initial 82 patients an average of 9 years after their injuries. [4] The study showed an overall increase in function and only very rare regression. These results were in sharp contrast to previously released data that influenced the current fatalistic perspective on these injuries. Over the course of the next ten years, Ruedi's findings were corroborated by Heim and Nasers results as well as by Ovadia and Beals'. The authors of these papers stated that, in accordance with the Arbeitsgemeinschaft für Osteosynthesefragen (AO) approach, open reduction and internal fixation (ORIF) produced the greatest results for them. Higher-energy axial-loading motor vehicle crashes were found to be the cause of more injuries in North America than torsional, comparatively lower-energy mechanisms of injury in Ruedi's original patient cohort. Furthermore, it's possible that the soft tissue handling procedures were not as sophisticated as those used to treat the osseous damage. Wrysch et al. observed that a significant proportion of patients at urban trauma centers suffered injuries from axial compression forces, leading to severe articular comminution and a significant soft tissue injury. This is contrary to the population of skiing accident patients that Ruedi documented. [5]

The advent of external fixators has helped in considerable reduction in the number of infections that prevailed in the past owing to the severe soft tissue injuries, elaborate surgical approaches and bulky implants. [6].Bone et al. presented their outcomes using hybrid of internal and exterior fixation procedures in a series of high-energy pilon. The procedure included open reduction, screw stabilization of the articular surface, and external fixation that stretched across the ankle to mostly neutralize the distal metaphyseal fracture until union. In the open and closed fracture groups, there were no serious infections; nevertheless, three fractures requiring bone grafting had delayed unions. The authors credited external fixation's enhanced ability to handle soft tissues for the reduction in problems. When compared to open-plating procedures, other investigators also observed a similar decrease in deep wound problems with the application of external fixation. [7]. The application of external fixation resulted in a new set of issues, including higher rates of nonunion and malunion, reduced clinical scores, and a delayed return to function. Significant rates of tendon damage, pin-tract infections, and neurovascular structure implementation with tensioned wire fixators were found in later studies. [8] They waited for a time period for the soft tissue injury to heal prior to internal fixation as the results of external fixations were equivocal and better understanding of the need of a healthy soft tissue cover. Schatzker and Tile distinguished between a soft tissue envelope that is suited for an initial major surgical procedure and one that is not due to the appearance of fracture blisters or significant edema in their 1996 textbook. The latter group was advised to wait seven to ten days before undergoing definitive fixation in order to give the skin and soft tissues time to heal and return to a "reasonable" state. It was advised that the limb get closed reduction and plaster splint immobilization, skeletal traction, or external fixation until the soft tissue lesion healed. [9] Before this, Mast suggested that if definitive surgery could not be performed within 8 to 12 hours, temporary treatment should be administered, and the definitive procedure should be delayed for 7 to 10 days to allow swelling to subside. The author advised that length-stable injuries could be managed with casting, while fractures with shortening could benefit from a period of calcaneal traction to restore or slightly distract fracture fragment length. [10] Hontzsch also noted the benefits of two-stage treatment in his experience with 50 tibial pilon fractures, using external fixation as a temporary measure. [11]

In the past decade, there has been a shift in approach to pilon fractures giving greater importance to the affected soft tissue. This has led to the widespread adoption of staged management for tibial pilon fractures, as highlighted in 1999 by separate reports from Sirkin et al. and Patterson and Cole. [12] . These studies stated that higher rates of infections were the result of immediate fracture fixation through a compromised soft tissue bed. Despite progress in identifying, understanding, and treating the associated soft tissue injuries, the widespread use of computed tomographic (CT) scanning, improvements in implant design, including locking plate technology, and minimally invasive application techniques, achieving satisfactory outcomes in managing these challenging fractures remains difficult.

OBJECTIVE

Primary Objective: To evaluate the functional outcome of delayed anterolateral plating for tibial pilon fractures done in a tertiary care center

Secondary Objective: To study factors associated with good functional outcome in patients undergoing anterolateral plating for tibial pilon fractures done in a tertiary center

REVIEW OF LITERATURE

RELEVANT PATHOANATOMY RELATED TO TIBIAL PILON FRACTURES

The relevant osseous anatomy of the tibial pilon includes the distal tibia, distal fibula, and talus. The articular surface of both bones of leg form a deep, box-like mortise that accommodates the superior dome of the talus. The articular surface of the distal tibia, rectangular in shape, forms the mortise roof, has a greater width anteriorly than posteriorly, and slightly concave from front to back [13]. The central part of distal tibial plafond is concave and has anterior and posterior extensions, with the posterior extension making a posterior arthrotomy for joint inspection impractical. The anterior tibia extends over the talus dome, allowing the entire tibial plafond to be viewed from anterior approaches.

The medial weight bearing surface is formed by medial malleolus which projects distally and anteriorly, presenting a chondral surface oriented roughly 90 degrees to the horizontal tibial plafond and articulating with the medial talar body. The lateral malleolus, the distal portion of the fibula, articulates with the lateral talus and has an important articulation with the posterolateral distal tibia, the distal tibiofibular syndesmosis. The maximum compressive strength of the tibial plafond is within approximately 3 cm of the articular surface, with minimal resistance in the trabecular bone beyond this distance. The strongest cancellous bone in the distal tibia is near the subchondral bone plate, providing an optimal area for fixation devices.

The relevant talus anatomy includes non-articular portions of the talar neck, useful for placing Schanz pins to facilitate talar manipulation and apply distraction across the ankle joint. The talar neck has more lateral area available than medial. The tibial plafond's orientation in the frontal plane is slightly valgus, with the lateral distal tibial angle around 88 degrees, and the mid-diaphyseal line of the tibia passing just medial to the talus midline. In the sagittal plane, the plafond is slightly extended, approximating 80 to 85 degrees, with the mid-diaphyseal line passing through the talus's lateral process (center of ankle joint rotation) when the foot is at 90 degrees to the tibia. Understanding these relationships is crucial during external fixation device application and indirect fracture reduction techniques. According to the author, radiographs of the contralateral ankle are the best reference for restoring each patient's unique osseous anatomy. When analyzing planes of safe surgical dissection and comprehending fracture displacement patterns, knowledge of the ligamentous attachments at the ankle joint is helpful. The distal tibiofibular syndesmosis is formed by the irregular convex surface on the medial aspect of the distal fibular and the irregular concave surface on the lateral aspect of the tibia.

The posterior, anterior, and strong interosseous tibiofibular ligaments, as well as the fibula itself, securely bind the fibula to the distal tibia in its distal half. The anterior tibiofibular ligament is attached to the anterolateral fragment also called as Chaput's fragment. [14]. It originates from this location and proceeds laterally and distally until inserting on the anterior part of the distal fibula. There are two halves to the smaller, more horizontally oriented posterior tibiofibular ligament: a deep component and a superficial component. The latter, often referred to as the transverse tibiofibular ligament, forms a labral articulation for the posterolateral talus by projecting below the distal tibia's border. The deltoid ligament is a robust, broad, flat triangle band made up of both deep and superficial fibers. The superficial fibers extend distally from the medial malleolus's anterior colliculus to the calcaneus's sustentaculum tali, the navicular, and the anterior section of the talus's medial tubercle [15]. The deep posterior talo tibial ligament, a posterior band that starts from the posterior colliculus and intercollicular groove and extends posterolaterally and distally to insert into the entire non articular medial surface of the talus, makes up the clinically significant deep portion of the deltoid. The primary stabilizer of the talus in the ankle mortise is this deep section of the deltoid ligament. [14] [15]. The tibialis anterior, the extensor hallucis longus (EHL), the extensor digitorum longus (EDL), and the peroneus tertius muscles are located in the anterior tibial compartment, arranged from medial to lateral. Distal approaches medial, lateral, and between these muscles can be used because all of these muscles are innervated by branches from the deep peroneal nerve proximally in the leg. The anterior tibial vessels and the deep peroneal nerve lies in the anterior compartment between EHL and EDL and care should be taken to protect them in direct anterior approach. The lateral compartment at the level of distal tibia consists if an anterior peroneus longus posterior peroneus brevis and the superficial peroneal nerve. The peroneal sheath securely attaches both along the distal fibula. The superficial peroneal nerve is entirely sensory in the distal third of the leg; it passes through the lateral compartment fascia and enters the subcutaneous tissue from posterior. The superficial posterior compartment consists of the gastrocnemius soleus and the plantaris muscles which are all supplied by the tibial nerve. The gastrosoleus merges distally to form the tendo Achillis that is a landmark in both posterolateral and posteromedial approach and has to be protected along with its paratenon in all posterior approaches. The deep posterior compartment consists of mainly three muscles Flexor Hallucis Longus (FHL), Flexor Digitorum Longus (FDL) and Tibialis posterior (TP). The tendons of these three muscles along with the posterior tibial vessels and tibial nerve pass through the posteromedial aspect of ankle through the tarsal tunnel and should be carefully protected in posteromedial approach to the distal tibia.. Rich extraosseous blood flow supplies the distal metaphyseal portions of the tibia, mainly from branches of the anterior and posterior tibial arteries. Numerous medial and lateral arterial branches that alight on the anterior distal tibial metaphysis surface are produced distally by the anterior tibial artery. The majority of the extraosseous vasculature to the medial and posterior parts of the distal tibial metaphysis is supplied by the posterior tibial artery. These branches form a complex circulatory network on the medial portion of the distal tibia by anastomosing with branches from the anterior tibial artery. Furthermore, the posterior tibial artery supplies many extraosseous branches to the posterior side of the distal metaphysis immediately proximal to the tibial plafond as well as the medial malleolar region. There is a chance that this extraosseous blood supply will be disrupted both during the harmful procedure and when plates are applied to the distal tibia. [16]. While there is a virtually infinite variety of fracture patterns involving the tibial plafond, there are several common fracture characteristics that have been noted. After a tibial plafond fracture, the major ligaments of the ankle usually stay mostly intact and are linked to the three often found major fracture segments. The medial malleolar fragment, the posterolateral Volkmann fragment, and the anterior (Chaput) fragment are the three fracture fragments that have lately been traced out using CT images. These fracture segments usually maintain connections with parts of the deltoid (medial malleolar segment), posterior tibiofibular ligament (posterior malleolar segment), and anterior tibiofibular ligament (anterolateral tibial segment) in cases of complete articular injuries (OTA/AO C-type fractures). The number of fragments and the corresponding comminution increase with increasing complexity. Areas of comminution and impaction, which typically involve the central and anterolateral portions of the tibial plafond and correlate the axial load and cephalad displacement of the talus within the distal tibial metaphysis at the time of injury, can be identified within the intersection of these major fracture segments. Any part of the tibial plafond may be injured partially, although the anterior plafond, the medial malleolar section, or combinations of these are most frequently affected. In order to detect even the smallest areas of impaction in these partial articular injuries, it is imperative that the intact tibial plafond be closely examined in the vicinity of the fracture. Clinically, there is often significant chondral damage along with tiny zones of comminution on the cracked edge of the intact segment, which can impede an exact reduction. The anterolateral, posterolateral, and medial malleolar fracture fragments' fracture morphology have been further defined by Topliss's by defining in details about the principal fracture lines at the level of distal tibial articular surface using CT imaging [17]. When treating distal tibia fractures, the fibula's condition is crucial to surgical consideration. Fractures caused by axial loading forces at the tibial plafond usually show comminuted fibula fractures with transverse and oblique fracture plane orientation, in contrast to rotational injuries of the ankle. OTA/AO C-type distal tibial plafond fractures seem to be more frequently linked to fibula fractures than partial articular (B-type) patterns. The study also concluded that tibial plafond injuries with fibula fractures looked to be more radiographically serious than those without fibula fractures, using a rank-order approach [18]. Tibial plafond fractures that appear with valgus angulation are typically associated with compressive fibula failure, while fractures that occur with varus angulation are typically associated with tension fibula failure. Simple fibula fixation methods, like tubular plates, may not be sufficient to achieve the necessary stability due to the mechanism and intrinsic lack of stability associated with comminuted fibula fractures that occur in the setting of tibial plafond injuries. Restoration of fibula length, alignment, and rotation will significantly affect the indirect realignment of the posterolateral and anterior tibial plafonds from their attachments to the tibiofibular syndesmotic ligaments. Any alteration in the distal fibula's length or rotation will be mirrored in the distal tibia's anterolateral and posterolateral segments. Similarly, angular deformity of the distal fibula in either plane will affect distal tibial reduction as both bones are closely articulated at the level of syndesmosis. Furthermore, the talus beneath the tibia's anatomic axes is indirectly reduced by the anatomic realignment of the fibula. It is crucial to recognize that fibular malalignment or residual shortening may consequently significantly impair three key processes: (1) reducing the distal tibia's articular surface; (2) restoring distal tibial alignment; and (3) the final reduction of the talus beneath the tibia.

MECHANISM OF INJURY IN TIBIAL PILON FRACTURES

The majority of plafond fractures of distal tibia are caused by high-energy events that transpire in motor vehicle collisions, industrial accidents, falls from elevated platforms, and motorcycle mishaps. While most pilon fractures of the distal tibial weight-bearing surface are caused by axial loading forces, where the talus is forced proximally into the distal tibia, resulting in the "explosion" fracture of the articular surface, malleolar ankle fractures are usually the consequence of lower-energy indirect rotational forces [19]. The prognosis, soft tissue damage, accompanying injuries, and fracture patterns are markedly varied as a result of these two primary causes of injury. Axial loads are generally applied more quickly than rotational forces are. Because bone is viscoelastic, it absorbs more energy before failing and releases it when it fails, transferring the energy to the envelope of soft tissue. This release of energy is what causes the significant swelling and blistering observed in these injuries, even in the absence of direct trauma to the soft tissue envelope. There is undoubtedly a range of injury outcomes, with axial or rotational forces accounting for the majority of combined causes. The eventual fracture pattern is dependent upon the direction and pace of application of the damaging force, as well as the foot's location at the moment of loading, as first proposed by Bohler [20] and further explained by Ruedi [3]. Wide differences in fracture patterns arise as a result. While impact with the foot in the neutral position results in substantial central comminution, impact with the foot in dorsiflexion produces cephalad and anterior force, leading to extensive anterior plafond comminution. In comparison, the posterior plafond damage patterns are far more prevalent and are believed to occur during plantarflexion. However, there are significant differences in fracture patterns depending on the exact orientation and location of the foot at the time of impact

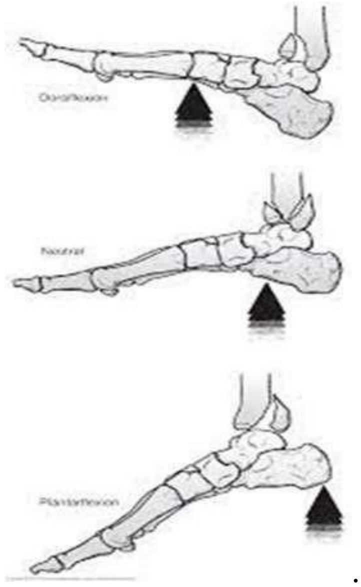

Fig1. Types of impactions in pilon fractures

The emergence of high-speed motor vehicle travel, enhanced automotive restraint systems, and improved trauma care systems that save lives have led to a rise in the number of orthopedists dealing with axial load-type intra-articular distal tibia fractures. Vehicle restraint systems now neutralize the same forces that may have previously been applied to the head, chest, and/or abdomen region and caused the occupant's death;

however, these same forces are still applied to the lower extremities, leading to the progressively more common presentation of significantly severe extremity injuries, including distal tibia injuries. Although tibial plafond fractures can occur on their own, polytraumatized patients also commonly have them. Wide displacement, chondral impaction, concomitant fibula fractures, pronounced articular and metaphyseal comminution, and articular debris are frequently seen. The high- energy process is supported by the prevalence of open wounds, deep abrasions, fracture blisters, and the osseous and soft tissue devitalization that goes along with them. Rotational forces can cause intra-articular distal tibia fractures, which often have a spiral direction and little to no fracture comminution. The articular injury consists of large articular fragments that are weakly to moderately displaced, with little to no chondral impaction or rupture. Although there is minimal damage to the soft tissue envelope, there may still be substantial edema. Significant devitalization from open wounds is uncommon, and the prognosis is better.

CLINICAL FEATURES

The surgeon can evaluate the possibility of skeletal or other system injuries, the likelihood of significant soft tissue swelling and blistering of the distal tibial soft tissues, and other factors based on the patient's history and the amount of energy involved. The history of medical comorbidities and nicotine use is very significant, and it should be well documented, since it may have a bearing on the surgical approach. Additional details gleaned from the history include the patient's job, the extent of schooling, the support networks within the family, and if the injury was the consequence of an accident at work. These are factors that seem to influence the functional outcome [21]. It is important to pinpoint the exact site of the injury as it may influence the kind and level of infection in open fractures and determine the course of any further antibiotic therapy. In order to fully evaluate tibial plafond fractures, the soft tissue envelope must be examined. This examination should be carried out logically, consistently, and circumferentially. Assessed and recorded are the extent of edema, the seriousness of contusions, and the existence of cuts, blisters, open wounds, and compartmental syndrome. Widely dispersed fracture fragments can occasionally cause severe skin strain and compromise the circulation of the surrounding skin. Under these circumstances, it is imperative to promptly rectify these severe malformations by hand before radiological evaluation in order to prevent additional vascular damage to the surrounding skin and soft tissues. The pedal pulses can be palpated, examined with Doppler ultrasonography, and the color and warmth of the foot are used to assess the vascular state. Changes in sensation are assessed in the plantar and dorsal portions of the foot. Intravenous antibiotics are started, visible foreign objects and debris are removed, sterile saline irrigation is used, and a sterile bandage is applied to heal open wounds. In these injuries a bone piece may get stuck below the skin and crushes the soft tissue cover and underlying skin.

This happens frequently when the anteromedial skin of the distal tibia is penetrated by the distal region of the tibial shaft, endangering the skin at the distal portion of the incision. To prevent additional harm to the anteromedial soft tissues in this case, reduction of the extruded fragment should be tried. The limb is straightened and fitted into a temporary splint that doesn't obstruct radiographic detail once it has been assessed. Fracture blisters are commonly seen in conjunction with noticeable edema following distal tibia fractures. After injury, fracture blisters usually develop quickly—often within hours—but they can also take up to two or three days [22]. Both fracture blister subtypes were shown by histologic examination to exhibit cleavage injuries at the dermal–epidermal interface. The primary distinction between clear- and blood-filled blister types was the clear-filled blisters' partial epidermal cell retention, which the authors thought indicated a more superficial damage and accelerated re epithelialization. On the other hand, the blood-filled subtype's dermis had no epidermal cells at all, which may have caused a longer delay for re epithelialization and indicated a deeper insult to the papillary vasculature. When a bone fractures, the skin becomes distorted due to bony displacement, which causes disruption of the dermal–epidermal junction and the subsequent production of fracture blisters. While there are few data in the orthopedic literature about the therapy of fracture blisters, hemorrhagic blisters seem to be linked to higher rates of complications, scarring, and postponed surgical intervention. Fracture blisters can be treated in a few ways: (1) sterile unroofing with Silvadene and/or nonadherent dressings applied; (2) sterile aspiration while maintaining the overlaying roof; and (3) leaving the blister unbroken. There isn't any strong evidence to favor one approach over another [23].

CLASSIFICATION OF TIBIAL PILON FRACTURES FRACTURE CLASSIFICATION

The Ruedi–Allgower [3] method and the OTA/AO Fracture categorization method are the two primary categorization schemes used for tibial plafond fractures [24]. Both systems just infer the degree of harm; they are descriptive systems. The Ruedi–Allgower system [3], which classifies tibial plafond fractures into three groups depending on the amount of articular comminution and displacement of the fragments. Intra-articular fractures without displacement are classified as type I fractures. With type II fractures, there is displacement of articular fragments but no comminution. Articular pieces are displaced and ground down in Type III fractures. The Ruedi–Allgower [3] system has demonstrated low intra observer and interobserver agreement.

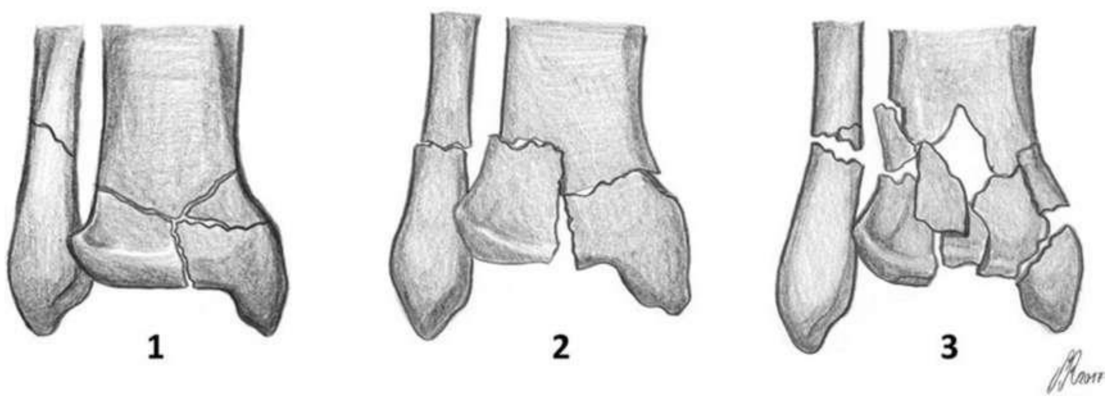

Fig 2: ruedi – allgower types of pilon fractures [25]

However, a better classification is given by AO /OTA which includes all fractures of distal tibia including the extra articular fractures. [24] Every bone is given a distinct number, and fractures are categorized using a standardized system. The number 43 is allocated to the tibia. Then, tibial plafond injuries are classified as extra-articular (43 type A), partly articular (43 type B), or entire articular (43 type C) injuries. Afterwards, each kind is separated into one of three categories based on the degree of fracture comminution.

Fig 3: AO classification [26]

The surgical treatment for tibial pilon fractures has evolved as a result of the identification of the soft tissue injury linked to these fractures. This is a crucial therapeutic aspect, yet there is still no clinically helpful categorization system to direct treatment. What has become evident is that recognizing and addressing the soft tissue injury is as important as managing the bony injury. Consequently, the cornerstones continue to be a comprehensive assessment of the soft tissue envelope and the experience and judgment of the individual surgeon.

Tscherne and Goetzen's subjective soft tissue injury categorization system places closed fracture soft tissue injuries into one of four groups, ranging from 0 to 3 [27]. Closed fractures that show no discernible soft tissue injury are grade 0 and show an indirect fracture with a simple pattern. Grade I soft tissue injuries show superficial abrasion or contusion of skin; simple or medium-energy fracture patterns are evident with displaced fracture fragments applying pressure to the skin. Grade II injuries show deep abrasions and local contused skin; medium to severe fracture patterns are identified; the grade II injury may also show signs of an impending compartmental syndrome. Lastly, grade III injuries show extensive contusions or crushing, significant muscle destruction, and subcutaneous tissue degloving. Compartmental syndrome, vascular injuries, and severe fracture comminution and a high-energy mechanism are frequently identified as part of grade III injuries. The observer reliability and repeatability of the Tscherne and Goetzen technique of categorizing soft tissue injuries have not been assessed, despite the approach's extensive discussion in the literature. While higher-energy traumas frequently show more fracture comminution and worse soft tissue injuries, the opposite is not always true. The amount of soft tissue injury does not always change directly with the OTA/AO fracture categorization. It is crucial to assess and categorize the soft tissue injury independently of the fracture pattern, even if the underlying fracture type may give an indication as to the extent of soft tissue injury.

TREATMENT OPTIONS FOR PILON FRACTURE NONOPERATIVE TREATMENT OF PILON FRACTURES

A number of authors have noted the same consistent difficulties with cast treatment: (1) the inability to maintain the talus from its common anteriorly and superiorly displaced position; (2) the inability to accurately realign or reduce displaced osteochondral fracture fragments; and (3) trophic impairments secondary to prolonged joint immobilization [19]. While it does represent the minimum risk for soft tissue injury, complications from skin necrosis may still arise because of local skin ischemia from displaced fracture fragments. Several decades ago, the purely conservative treatment of pilon fractures using closed reduction and plaster cast immobilization had largely been demonstrated to have relatively poor functional results, leading to its abandonment in favor of operative therapy. Consequently, patients who have a significant or absolute contraindication to surgical management, such as non ambulatory patients, patients with a very poor soft tissue envelope, and/or patients with a tenuous vascular supply to the limb, should save their nonoperative management for fractures that are truly nondisplaced. Non operative treatment options for pilon fractures are limited. In cases such as (1) inadequate lateral soft tissue envelope, (2) extensive fibular comminution with a relatively simple tibial injury, (3) overt or functional tibial bone loss that will be treated with tibial shortening, (4) open medial wounds where the allowance of fibular shortening simplifies or speeds up medial tibial wound closure, and (5) minimally displaced fractures, nonoperative treatment for fibula fractures may be a more sensible option. Similarly, nonoperative treatment is frequently used for mid-to proximal fibular shaft fractures. Closed manipulative reduction and cast immobilization is the management option for patients receiving nonoperative treatment, and the decision is made depending on the amount of comminution and the degree of instability. Usually, six to twelve weeks following their injury, progressive weight bearing with ankle and subtalar range of motion is started depending on radiographic recovery. When the patient's general health permits, individuals who have sustained severe injuries or illnesses with significant soft tissue damage, fracture instability, and displacement can be treated with calcaneal pin traction before being placed in a cast. Closure of the talus and cast immobilization frequently did not stop the talus from moving anteriorly and superiorly, according to Rouff, who recognized that keeping the tibiotalar connection intact was crucial to regaining ankle function [19]. Ayeni discovered that although casting and closed therapy had favorable outcomes in fractures with limited displacement (Ruedi type I), a considerable proportion of displaced fractures had bad outcomes, and she believed that casting was not even useful in cases where there was extensive comminution [28]. In a brief series of comparisons, Kellam observed that the outcomes of surgical intervention outperformed nonoperative intervention in cases with tibial plafond injuries, including those involving rotation and compression [29]. Bourne [30] [31] assessed 42 tibial pilon fractures that were categorized using the Ruedi-Allgower criteria. The authors observed that closed therapy yielded worse outcomes than open treatment in every type of fracture, with increasing comminution and displacement (types II and III) consistently showing poorer outcomes [31]. All of these studies' findings together show that casting is useless for preserving limb length and minimizing damaged articular segments, especially in cases of severe axial loading injuries resulting in considerable displacement and comminution. The persisting varus tendency in such intra-articular distal tibial fractures with intact fibula makes it challenging to maintain limb alignment using nonoperative approaches. Similarly, it is common for displaced partial articular injuries to show evidence of talar displacement inside the mortise, which is unmanageable with closed methods. Closed therapy has drawbacks, but for many patients—such as those who are bedridden, have limited mobility, or have functional demands—it remains the recommended approach to management. Furthermore, individuals may be candidates for closed therapy if they have major concomitant medical conditions.

OPERATIVE TREATMENT OF PILON FRACTURES

Surgery is used to treat most displaced distal tibial fractures, especially those in which there are displaced intra-articular fracture fragments. The best surgical treatment method hasn't been decided upon yet, though. Treatment options for unstable, displaced extra- articular distal tibial fractures include plate fixation [32], external fixation[33], open or percutaneous reduction, and combinations of these methods. The surgical management plan depends mainly on the type of fracture and the condition of soft tissue. The management of distal tibia intra-articular fractures follows the same guidelines. Using finite element modeling, Anderson et al. defined that when pilon fractures are managed surgically there exist a threshold of stress beyond which those fractures fixed incongruously are bound to result in early osteoarthritis [34]. The data obtained from the closed management of displaced intra-articular distal tibial pilon fractures strongly suggests that the tibiotalar joint poorly tolerates articular incongruity and talar subluxation. However, the extent to which posttraumatic arthrosis, residual articular incongruity, and the necessity for further surgical intervention are impacted by residual articular incongruity is still up for debate Thomas et al. quantified the features of acute pilon injuries using new CT-based image processing [35]. The scientists then developed a composite severity score that included fracture energy and articular disruption, which allowed them to predict the severity of posttraumatic arthrosis. In patients who are appropriately chosen, a palpable incongruity at the tibial plafond that is proven on plain radiographs should be regarded an indication for operational reduction and fixation, even if there are no precise standards for defining how much articular step-off or gap can be allowed. External fixation, which can be utilized alone or in conjunction with staged ORIF, has become an essential part of the therapy of tibial pilon fractures. In the latter case, the external fixation device is always positioned above the ankle joint, immobilizing it (thereby enclosing the foot in the construct). Its purpose is to provide temporary stability and alignment of the gross fracture while soft tissue heals and allows for definitive ORIF. The most frequent justification for using external fixation in the former case is to achieve and maintain reduction of the distal tibial metaphyseal fracture, eliminating the need for plate stabilization in this region and lowering the risk of serious wound complications that were previously linked to open plate fixation. Despite the positive outcomes that Bone et al. observed with ankle-spanning external fixation in cases of severe tibial pilon fractures [36], worries about extended ankle joint bridging led to the development of two alternatives for external fixation: those that cross the ankle joint and those that do not. Ankle-spanning systems usually consist of a unilateral fixation frame that is fastened at the calcaneus, talus, and medial border of the tibia shaft. This creates a bridge that spans the ankle joint. Ankle- sparing systems are usually a combination of circular, tensioned thin-wire systems and unilateral frames, or a fully tensioned thin-wire system with Illizarov's famous circular rings. In the previous approach, half pins are inserted proximally into the tibial diaphysis and a fixation ring is applied distally using tensioned wires to attach the epiphysis to the circular sections of the frame. It may be possible to articulate a version of the ankle-spanning system that would allow for the potential advantages of ankle mobility while preserving the stability of the epiphyseal fracture portions during the osseous healing period. The surgeon can choose to use restricted incisions in conjunction with percutaneous screw insertions, or they can use normal incisions and methods to manage the articular reduction while employing external fixation devices. To stabilize distal tibia fractures solely on the tibial side of the tibiotalar joint, a variety of external fixators and fixation devices are available.

Clinical use using hybrid Illizarov fine-wire ring fixators [37]—which usually combine half-pin fixation proximally with fine-wire fixation of the distal tibial segment—and pin-only fixators [38] has been documented. As compared to previous plating methods these external fixators had lower wound related complications post operatively. While there are still occasional infections over the distal tibia, with reports of 4% to 13% in various series, overall union rates have been high, with reports of 75% to 81% good and excellent outcomes. The limited safe corridors available for wire implantation, which might lead to tendon impalement or neurovascular damage [39], are a drawback to tibiotalar sparing external fixation. Certain comminuted distal tibia fractures are not amenable to same-side external fixation, with some authors suggesting that the presence of 2 cm of intact bone is necessary to achieve adequate stability. This is because the stability of the distal tibial metaphysis depends on stable fixation into the epiphyseal segment. Septic arthritis of the ankle due to juxta-articular wires at the level of the tibial plafond has been recorded [40], but less frequently than in the tibial plateau. This suggests that using external fixator pins or wires in the area of damage to stabilize high- energy distal tibia fractures does not exclude the possibility of serious deep wound consequences. As a result, very distal injuries provide a therapeutic challenge since pins inserted less than 2 centimeters from the joint line, especially when passing through the distal tibiofibular articulation, may be intracapsular, and a superficial infection of these pins might lead to septic arthritis. However, a recent study by Katsenis et al. shown the effectiveness of hybrid external fixation in treating tibial pilon fractures with significant metaphyseal comminution [41]. By combining hybrid external fixation with open reduction of the articular surface, the authors were able to achieve acceptable outcomes in individuals with modest metaphyseal comminution (1 to 3 cm) A trans articular spanning pin fixator is a great way to stabilize the ankle temporarily, especially when there is a high-energy tibial plafond fracture. External fixator is used as a part of initial surgical procedure immediately following the injury to stabilize the limb and to aid in soft tissue healing until a second stage procedure is done at a later date [42]. However, it is not as often utilized as the gold standard for balancing forces during fracture healing. The fact that trans articular spanning external fixation is the most easily applied type of fixation is one of its main benefits. Furthermore, it is the safest to use since the skeletal fixation components do not breach the wounded soft tissue envelope or the fractured distal tibia because the zone of injury is usually not violated during its administration. Temporary trans articular spanning external fixation preserves limb length, alignment, and rotation in an indirect manner until a final treatment plan is determined. This helps in early recovery of the soft tissue insult and in majority of cases have to be augmented by other final treatment techniques, such as the subsequent use of plates, screws, conversion to hybrid fixation, or combinations of these. As a last resort, stabilizing the distal tibia may be accomplished with a spanning fixator [43]. The articular surface is reduced and internally repaired, either percutaneously, by restricted open approaches, or with more extensive open reduction. The spanning fixator serves to neutralize the fracture. When compared to open procedures, definitive tibiotalar spanning external fixation for tibial plafond fractures has been shown to have poor overall results, loss of reduction, ankle and hindfoot stiffness, and malunion. Limited ankle motions are possible during the course of therapy with articulated fixators, which were made famous by Marsh et al [44]. They work by using a hinge that is roughly positioned at the ankle's center of rotation. Initially, articular visualization and reduction can be facilitated by using the fixator to distract the tibiotalar joint. In order to aid with articular visualization and reduction, the fixator can first be employed to divert attention from the tibiotalar joint. After that, the device is employed to keep the distal metaphysis reduced. Marsh claims that because one of the hindfoot pins is integrated into the talus, it is possible to precisely manage the talar location underneath the tibia and to partially reduce the distal fibula, which frequently eliminates the requirement for internal fibula repair [45]. But because the subtalar joint and the neurovascular bundle are so close together, it's important to place the pins in the hindfoot precisely. The amount of ankle mobility following surgery will be restricted if the hinge is not precisely centered with respect to the estimated axis of ankle rotations. Additionally, the subtalar joint is immobilized while the fixator is in place because pins are inserted into the calcaneus and talus. Averaging thirty months following the injury, Marsh conducted a prospective examination of thirty-one fractures treated with minimal incision articular reduction and stabilization with medial articulated external fixation [46]. While one-third of patients reported an acceptable or excellent outcome, almost half were evaluated as poor. Deep infections were not present. Increased clinical experience with the articulated external fixator for tibial plafond fractures has also revealed good patient outcomes, a high union rate, and a low incidence of major sequelae. Maintaining tibial length, alignment, and rotation and reducing the soft tissue damage associated with surgical fixation is the main goal of providing external fixators in pilon fractures. Ligamentotaxis is used to indirectly achieve reduction. But when it comes to treating the articular damage, the surgeon has choices. One method is to use common surgical techniques to get a real open reduction. The external device is utilized to neutralize the metaphyseal damage once the articular surface is viewed and fastened with a number of screws. A different approach is to perform limited or small-incision reductions, with fixation using cannulated screws or percutaneous wires. To accomplish articular reduction and interfragmentary compression, the surgeon must be able to plan the location and direction of lag screws or tensioned small-diameter olive wires based on the articular fracture morphology from the CT scan. This knowledge also makes it easier to interpret intraoperative fluoroscopic views of the quality of reduction. Finally, in some cases, open reductions of the articular surface of any kind are not recommended because of soft tissue limitations or related injuries that prohibit patients from requiring a lengthy surgical procedure. In these cases, the primary goals are to restore distal tibial alignment and preserve the talus centered beneath the mechanical axis of the tibia, and if union is achieved with satisfactory alignment, the patients' future reconstructive procedures may be made easier by the absence of surgical incisions and implants. Operative stabilization is always used to treat accompanying displacement fibula fractures when ORIF is selected as the final treatment for a displaced plafond fracture. According to Ruedi, the first of four successive criteria for the effective management of these fractures is regeneration of the proper fibular length [47]. On the contrary, there is a lot of debate over the best course of action for treating concomitant fibula fractures when external fixation is employed. Williams et al. observed major problems related with fibula plating, including wound infections, nonunion, and malalignment, in a study of tibial plafond fractures treated with external fixation, despite the fact that many writers claim that this step is crucial in aligning the limb [48]

OPEN REDUCTION AND INTERNAL FIXATION

Ruedi and Allgower's seminal English language manuscript from 1969 described a four- principle ORIF of the tibial plafond that showed a significant improvement in functional outcome, complications from arthrosis, and a minimal treatment complication rate compared to nonoperative management [49]. This landmark article would become the benchmark for the treatment of these injuries with only 3 of 84 consecutive patients developing a deep wound infection. The original description of these four principles consisted of restored anatomic fibula length, anatomic restoration of the distal tibial articular surface, bone grafting of metaphyseal defects, and stable fixation of the fracture through medial buttress plating.

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IMMEDIATE (ACUTE) ORIF

As it makes sense, ORIF is best carried out as soon as possible after the injury, before organizing hematoma, soft tissue contraction, callus formation, osteopenia, and bone resorption secondary to the early inflammatory response have developed. The authors noted that, as stated by Ruedi and Allgower in their study some of the patients could not be managed with immediate ORIF, including those with severe soft tissue injuries, polytrauma patients with multisystem injury, some fractures that were not amenable to primary ORIF, and fractures that were not amenable to it. Overall, a high quality of reduction was observed with a medium-term outcome that compared favorably with other treatment modalities. While immediate (acute) ORIF for tibial pilon fractures is still an effective therapeutic option, it should be used cautiously. Implementing final therapy within 48 hours of injury, having a surgeon with experience managing high-energy tibial pilon fractures, and having a hospital with sufficient resources are all essential for success.

STAGED ORIF

Anatomic articular reduction and anatomic restoration of the distal tibia's length, alignment, and rotation are the objectives of phased ORIF. Following a time of soft tissue healing, this is done. Leg length, alignment, and rotation are achieved during the first treatment, which frequently involves tibial external fixation, fibular reduction, and internal fixation. The development of a surgical strategy for every operation is a critical component of this therapy approach. Failing to do so might lead to difficulties and jeopardize the outcome.

Stage I: Fibular Open Reduction and Internal Fixation and Tibiotalar Spanning External Fixation

The first step of surgery focuses on reducing and stabilizing the osseous component of the fracture, with a special emphasis on restoring limb length, alignment, and rotation. However, the main focus is on how this affects soft tissue stability. This specifically refers to the removal of skin tenting, soft tissue deformation, ischemia regions caused by misplaced osseous pieces, and soft tissue length restoration. When it comes to joint vision during the later definitive ORIF, ideally, 2 to 3 mm of over distraction can help. However, the state of the soft tissue envelope, especially the skin and neurovascular systems, should be the primary factor directing the degree of distraction. Avoiding over distraction that might cause localized soft tissue vascularity, threatening limbs, or neurological impairment is imperative. It is believed, if at all possible, the surgeon performing the initial stage should also perform the definitive stage, or share a similar management philosophy. Surgeons not performing definitive surgery should not delay external fixation of a pilon fracture with soft tissue compromise, and placement of the fixator 4450 pins should be done with an understanding of the incisions that will be used later for definitive fixation. Critical elements of this stage include the exact placement of skin incisions, external pin placement, anticipation of where definitive tibial surgical incisions and implants will be placed, and the execution of optimal reduction of the fibula and tibial fractures. Some information indicates that fibular ORIF may not be absolutely essential to achieve the ultimate tibial alignment. According to certain studies, precise fibular ORIF greatly improves the indirect realignment of the distal tibia's articular and metaphyseal parts. [53]. Furthermore, fibular ORIF, as Kurylo proposed, is crucial for enhancing medial soft tissue conditions in tibial pilon fractures that manifest as lateral translation of the distal component and valgus [53]. Applying the same reasoning, however, a malreduced fibula fracture that is securely stabilized can pose significant challenges to achieving precise tibial articular reduction and tibial alignment. Anticipating any skin incisions (for this and subsequent stages), debridement of any open wounds, ORIF of a concomitant fibula fracture, closed manipulative reduction, and temporary spanning external fixation of the tibial plafond fracture are the main characteristics of this step. Selecting the best fibular fixation will be made easier by closely examining the injury radiographs to see if the related fibula fracture failed mostly in compression, tension, or rotation. Usually, the first step consists of external fixation and fibular fixation. Likewise, posterolateral Volkmann pieces that are rotated or extensively displaced may also be treated in the first phase. Even though this is an uncommon occurrence, the same posterolateral skin incision can be used to treat both the fibula fracture and the posterolateral Volkmann fragment if a thorough preoperative strategy is followed. Nonetheless, at this early phase, the surgeon must avoid doing rash open tibial reductions.

Positioning

On an operating table that is radiolucent, the patient is put supine. A soft supportive bump or roll is placed beneath the ipsilateral buttock, flank, and shoulder region to minimize the tendency for the entire limb to externally rotate. A firm foam ramp or cushion is put beneath the injured extremity to slightly bend the ipsilateral hip and knee, and elevate the leg, thereby allowing easier access to the posterolateral portion of the fibula and to provide unobstructed lateral fluoroscopic imaging of the foot, ankle, and tibia. To prevent a brachial plexus traction injury, the ipsilateral arm is crossed over the chest. Particularly the fibular head and the lateral malleolar areas of the contralateral leg, all bony prominences should be cushioned. Rarely is a tourniquet used. The leg is free draped down to the mid-thigh, shaved, and aseptically prepped. Within sixty minutes following the surgical incision, an antibiotic of the first-generation cephalosporin is given. The image intensifier is brought in from the contralateral side of table. It is ideal to observe the monitor near the foot of the bed when performing surgical fixation of the fibula. It is best to place the monitor closer to the head of the bed when applying external fixation, especially when applying traction to the foot.

Surgical Method

For a tibial plafond fracture, it is recommended to make the skin incision for fibular fixation slightly posterior to the palpable posterior fibula border, rather than using a straight lateral incision typically used for simple fibula fractures. This approach enhances the soft tissue bridge and allows for the possibility of using the same incision for an anterior exposure if tibial fixation is required and for a posterolateral tibial approach at a later stage. Despite the fact that a 7-cm skin gap is recommended [54].The incision is located just posterior to the palpable posterior border of the fibula, is longitudinal, and is centered over the fibula fracture. The lateral compartment fascia is longitudinally incised along the whole length of the skin incision, and dissection occurs directly through the subcutaneous tissue. The anterior edge of the incised fascia is then retracted anteriorly and the peroneal musculature is retracted posteriorly. To sustain vascularity to the skin, attention is made to minimize the development of planes between the subcutaneous tissue and the fascia over the lateral compartment. Depending on the position of the fracture, the superficial peroneal nerve may be contacted within the lateral compartment before exiting the fascia and moving within the subcutaneous layer

Fibular ORIF: Key Surgical Steps:

A posterolateral incision is preferred for fibular ORIF, the fracture site is identified and the fracture type is noted reduction is attained and maintained and the reduction is checked for length alignment and rotation. If necessary, an interfragmentary screw can be placed followed by neutralization using a plate of appropriate length, the incision is then closed by the allgower donate suture technique using 3-0 nylon with knots facing posteriorly. Since fibular fractures are common in pilon fractures, reduction of fibula will help in further reduction and stabilization of the plafond fractures. A well reduced fibula facilitates the congruous alignment if the tibiotalar joint which is essential at the end of the first step surgery as it will help in healing of the soft tissue injury. On the contrary if the fibula is malreduced it can lead to tibiotalar malreduction and anterior translation of talus over the tibial plafond ultimately leading to anterior talar extrusion from the tibial articular surface.

Hence in majority of the cases fibular reduction is performed prior to tibial reduction and external fixation however in rare circumstances a reversal of order may be necessary. In conditions when there is gross instability or greatly communited fibular fractures we may first have to do external fixation to restore the length rotation and alignment. With the distraction achieved by the external fixator fibular fixation is done. This method may also be employed in cases where the tibia has sustained a relatively simple fracture when compared to the fibular fracture

Acute Tibial Internal Fixation

Many a times pilon fractures are associated with a posterolateral Volkmann's fragment and this fragment needs fixation. However, it is difficult to approach this fragment through the anterior approach and hence it is recommended to fix this fracture in the first step procedure via the posterolateral incision along with fixation of fibular fracture [55]. Identification of tis fragment is also important in deciding on the position of the patient on the table as it warrants lateral decubitus or prone position as opposed to supine position which is usually opted in fixing fibular fractures. While prone position helps in easier reduction of the posterolateral fragment, the difficulty lies in applying the external fixator. Hence lateral decubitus position is preferred in case of an associated posterolateral fragment. The incision is made midway between tendo Achillis and posterior border of fibula. On retracting the peroneal muscles anteriorly towards fibula, the fragment can be visualized. The peroneal muscles and FHL are retracted posteriorly and the fibula is visualized and fixed with a tubular plate. The surgeon then revisits the posterolateral fragment, reduces it and fixes it with mostly a unicortical screw to prevent any hindrance to future fixation. This mostly brings the tibiotalar joint in congruity.

Tibiotalar Spanning External Fixation: Key Surgical Steps

The extend of the tibial fracture is determined using fluoroscopy and a 5mm Schantz pin is inserted away from the site of future plate fixation. A 5mm Denham pin is then inserted at the center of calcaneum. Now a 4mm Schantz pin is inserted over the medial aspect of the foot traversing the medial middle and the lateral cuneiforms. 2 AO rods are used to connect the tibial pin to the calcaneal pin and the calcaneal pin to the pin over the cuneiform. Another rod connects the tibial pin and the lateral end of the Denham pin. A second Schantz pin can be applied just distal to the proximal tibial pin and in turn connected separately to medial 2 pins to provide additional stability. Distraction is provided with fluoroscopic visualization of tibiotalar joint ensuring adequate reduction and congruity. The primary aim of externa fixator is to maintain the length alignment and rotation which can be confirmed by the dime sign and to prevent anterior talar extrusion maintaining the tibiotalar articular congruity. The foot is ensured in plantigrade position by manipulating the rod connecting the tibial Schantz pin and the pin over the cuneiform. Ligamentotaxis is usually used to achieve these objectives indirectly. Achieving an accurate and stable fibular reduction is one of the most influential indirect reduction methods for obtaining an accurate restoration of tibial length and alignment. Since this type of external fixation is only temporary, elaborate constructs are not necessary; the reduction must be rendered effectively stable as this provides a crucial element for soft tissue recovery.

Stage II: Definitive Tibial Pilon ORIF

After the initial stage a CT scan is mandatory to look at the reduction attained and the position of the fragments yet to be fixed. This will help us in determining the subsequent surgical approach to be chosen which helps us to address all the unreduced fragments and at the same time causes minimal insult to the sift tissue. The CT should be read in details giving utmost importance to the three principal fragments of the pilon injury namely: the medial malleolar fragment [56], the posterior (Volkmann) fragment, and the anterolateral (Chaput) fragment.

Usually, the anterior tibiofibular ligament, posterior tibiofibular ligament, and deltoid ligament are attached to the named fragments and these fragments may be communited and the central articular region of distal tibia may be impacted. Such cases may require newer implants such as fragment specific plates which may be anterolateral, posterolateral or medial malleolar plate that helps to buttress these fragments to the metaphysis using screws. The central impaction may rarely need augmentation with bone substitutes or bone grafting.

Surgical Approaches

The position and displacement of the main pieces, as well as the soft tissue characteristics in the area, determine which surgical method is best. There are several surgical exposures have been defined for surgical fixation of this complex articular fracture which are : the straight anterior approach, the classic and modified anteromedial approach, the anterolateral Bohler approach [57], the straight lateral approach [58], the posterolateral approach [59], and the posteromedial approach [60]. A better knowledge of the anatomy of the fragments involved in pilon fractures and the significance of preserving soft tissue has led to the description of percutaneous adjuncts, restricted arthrotomies, and indirect articular reductions, all of which have a role in addressing these injuries [61]. The most common management techniques for tibial plafond fractures by surgeons are modified anteromedial or anterolateral exposures. It is rare that posterolateral and posteromedial exposures are needed.

The Anteromedial Approach

This approach is excellent to visualize the medial aspect of the joint and is the approach of choice when there is a medial comminution with or without angulation. The main drawback of this approach is that soft tissue closure may be difficult following this approach particularly if a high-profile implant is used. The incision starts just lateral to the tibial crest and is directed towards the navicular just in front of the medial malleolus and just medial to the tibialis anterior tendon. [62]. Layer by layer incision is avoided and the primary incision to taken till the depth of the bone and the flap of tissue is retracted as a whole similar to the incision made in extensile lateral approach in calcaneal fractures. The capsule is then cut to enter the joint and visualize the fragments. Fixation of the anterolateral fragment may need a separate incision.

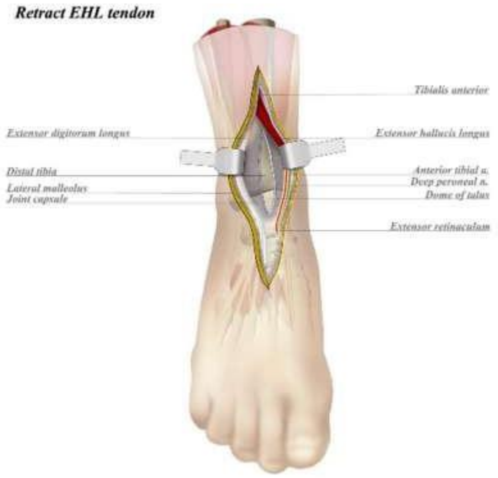


Fig 4: Anteromedial approach to tibia

Modified Anteromedial Approach

Assal et al. have recently reported a modest variation of the standard anteromedial strategy, which is the mostly preferred anteromedial exposure [63]. The advantage of this exposure is the greater visualization of the anterior medial and lateral tibial articular surface. The disadvantage of this approach however is that there is a sharp angle formed at the level of ankle joint that can go in for necrosis. Here the incision is curved medially at the distal part at an angle of about 105-110 degree. The horizontal part of the incision ends about 1cm distal to the medial malleolus and this extension is made after protecting the saphenous vein. The incision is extended to bone depth as in case of the classical anteromedial approach. The capsule is then incised to enter the joint space.

Fig 5: Modified anteromedial approach [64]

Anterolateral Approach

The anterolateral approach is the workhorse approach to approach distal tibia in contrast to the anteromedial approach where the soft tissue envelope is delicate and closure may be difficult following placement of implant. However, the two main disadvantages of this approach is that The visualization of the medial plafond is difficult via this approach

The proximal extension of this approach is limited to about 7cm above the ankle joint Still this approach provides perfect visualization of lateral, posterior and central fragments and these fragments can be easily fixed via this approach. [65].

The incision is a straight longitudinal one that is made along the fourth ray and upon retracting the skin and subcutaneous tissue the superficial peroneal nerve is visualized which is protected. Deeper dissection is done and the muscles of anterior compartment are retracted medially and we reach directly over the anterolateral fragment. The capsule is then incised to reach the joint and visualize the fragment. The proximal extension of the incision can be made up to 7 cm above the joint line and further proximal screws if any are placed percutaneously. If there are central or posterior fragments, their visualization is possible by externally rotating the anterolateral fragment. If there are medial fragments then a separate malleolar incision is put to do their fixation.

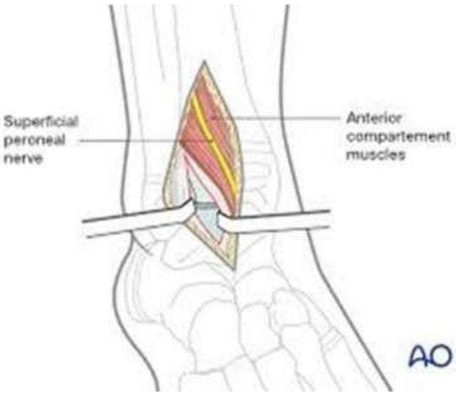


Fig 6: Anterolateral approach to distal tibial [66]

Posterolateral Approach

Posterolateral approach is the most common second incision made to address the posterolateral fragment. It is particularly important in unstable articular fractures or partial articular plafond fractures [55].Patient is positioned either prone or lateral position and incision is made midway between tendo Achillis and lateral malleoli deep dissection will show the tendons of the peronei muscles that is retracted posteriorly for addressing the fibular fracture and anteriorly to address the posterolateral fragment. The posterolateral fragment can be fixed with mini plates or screws. The position of fragment after reduction is confirmed in AP and lateral views by fluoroscopy.

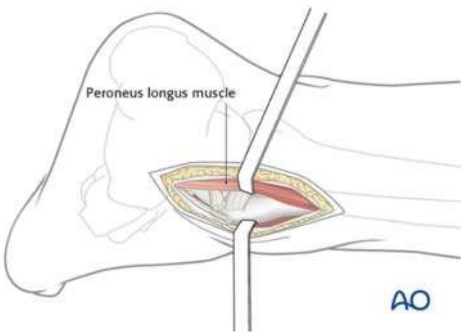


Fig 7: Posterolateral approach to distal tibia [66]

Posteromedial approach

The posteromedial approach is a rare approach and is used only if there is a displaced posteromedial fragment that needs fixation after open reduction. The incision is placed immediately medial to the tendo Achillis sparing its paratenon. The chief superficial structures encountered are the neurovascular bundle and the FHL muscle along with its tendon. Deeper layer has digitorum muscle. Deoending upon the position of the fracture fragment the FHL can be retracted medially or laterally to approach the fracture fragment. Proximal medial visualization may need mobilization of FHL.

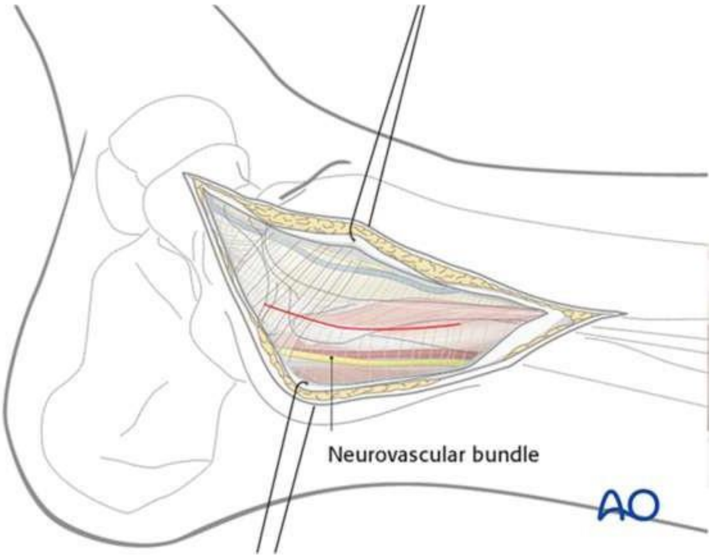


Fig 8: Posteromedial approach to distal tibia

Definitive Tibial Pilon ORIF: Key Surgical Steps

Reduction of pilon fractures depend on the fracture pattern. AO type C fractures are the most difficult to fix. After fibular fixation next step is to address the posterolateral fragment via the same approach. Further sequence of reduction involves fixation of the medial malleolar fragment to the posterolateral fragment. The impacted central communited fragment is then addressed and fixed to the posterior plafond. This is followed by the fixation of anterolateral Chaput" s fragment. Previous implants used for fixation were mostly bulky implants that caused wound dehiscence. They have now been replaced by low profile anatomic implants that can be fixed percutaneously and by indirect reduction techniques. The main aim of fixation is ti restore articular surface, to provide a rigid fixation and to maintain the length alignment and rotation. The number and choice of implants depend mainly an the degree of comminution, the deformity of the limb (varus/valgus/flexion/extension) and the position of fragments .

Ideally, the plate that we choose should be stiff enough to provide rigid fixation and should not be too prominent as the chance of implant exposure increases with greater profile implants. How ever a complete articular fracture like AO type C definitely requires a stiff implant in addition to other implants to maintain the alignment and to bear the load. Low profile buttressing implants can be used for partial articular fractures. Recent studies err on locking plates when it comes to intraarticular fractures as there is lesser chance of collapse and re exploration as compared to non-locking plates [55]. Wond closure is of great significance in pilon fractures and initially the capsule followed by extensor retinaculum and deep fascia are closed by absorbable sutures. The skin is closed by nylon using allgower donate fashion followed by application of steri strips for wound approximation.

Postoperative Care

Post operatively the limb is immobilized using plaster splints and the foot is kept in neutral position. Analgesics are given as multimodal pain relief regimen including, patient controlled analgesics, peripheral nerve blocks, epidural catheters. Narcotics and non-narcotic analgesics.. This often includes both long- and short-acting narcotic medications, regular doses of acetaminophen, and local pain control methods such as ice, elevation, and splinting. Gabapentin is added to the regime if the patient has neurogenic symptoms. Nonsteroidal anti- inflammatory medications are generally withheld for about three months to minimize the theoretical risk of delayed healing or nonunion. [67]. The wound is examined 4-5 days postoperatively and usually sutures are removes at 2-3 weeks until then the limb is kept in a splint. Physiotherapy is then initiated aiming at active, active assisted and passive movements of ankle joint, subtalar joint and other joints of the foot. Night time splints are given to avoid equinus contractures. At about 12 weeks partial progressive weight bearing is initiated giving due emphasis on maximizing motion, strengthening, gait training, and gradually weaning off ambulatory aids such as crutches, canes, and external supports. Postoperatively, edema can be significant and may persist for several months. Patients are educated about this normal phenomenon and provided with an elastic stocking to help reduce dependency-related swelling.

OVERVIEW OF MANAGEMENT

Stage I: Fibular ORIF and Tibiotalar External Fixation Fibular fracture is initially assessed for the following:

- The mechanism of the fibula fracture, such as tension or compression failure
- The degree of comminution

The mechanism of the fibula fracture often determines not only the fibular fixation construct but also suggests the direction from which the tibia should be primarily buttressed. Valgus, compression-failure fibula fractures often indicate that the distal tibial metadiaphysis may be best supported with a laterally based tibial plate, whereas tension-failure fibula fractures typically suggest the use of a medial tibial buttress plate. The degree of comminution helps in deciding whether a periarticular fibular plate is needed or if simpler tubular-type implants can be used. Simple transverse fractures in the distal third of the fibula shaft can often be successfully managed with medullary fixation, avoiding significant soft tissue dissection. The author aims for anatomic fibular length, alignment, and rotation.

Tibial fracture is initially assessed for the following:

- The posterolateral plafond injury (the Volkmann fragment)
- Any metadiaphyseal extensions that can be manipulated by closed techniques thereby concerting a Type C to a Type B injury
- The anterolateral plafond injury (Chaput's fragment)

Assessing the position of Volkmann fragment is crucial as it can be best managed concomitantly and acutely with fixation of the fibula fracture, thereby significantly easing the subsequent definitive treatment stage. Similarly, long spiral metadiaphyseal extensions or large oblique fragments with a substantial articular surface at their distal portion are considered for acute ORIF. The acute reduction of the above fragments can provide several benefits, including:

- Subsequent reduction can be made simple by percutaneous techniques or minimally invasive techniques.
- A better congruence between talus and tibia that can be held on using an external fixator.
- Anatomically reduced distal tibia will help in faster soft tissue recovery.
- A reduced, stable distal segment to fix on at the time of the definitive fixation

Acute partial tibial reduction and fixation is typically performed with short-length small or mini-fragment plates and/or independent screws, ensuring no inadvertent fixation of other unreduced fracture fragments. This strategy should only be executed when the entire definitive fixation construct has been planned out to avoid compromising the final choice of surgical approaches, implant placement, and soft tissue integrity. If the operative plan cannot be fully outlined at the outset due to inadequate understanding of the CT scan or if the soft tissue envelope is unsuitable for acute interventions, the author prefers to apply a simple external fixator, achieve as accurate a reduction as possible, and repeat or perform imaging as needed. It is far better to ensure the best surgical tactic, reduction, and fixation in three or more stages rather than proceeding with a poorly planned and executed surgical plan in two stages.

After accurate fibular fixation, a biplanar tibiotalar spanning external fixator is applied. This involves using a transcalcaneal pin, two tibial pins, and a single cuneiform pin. The biplanar external fixator is then used as the distraction device for the definitive tibial reduction and fixation stage. This requires accurate placement of the talus beneath the anatomic axis of the tibia in the frontal plane, slight posterior translation in the sagittal plane, and satisfactory tibiotalar distraction in the horizontal plane. Following fibular fixation and tibiotalar external fixation, a CT scan is obtained.

Stage II: Definitive Tibial Fixation

Definitive tibial reduction and fixation are performed once soft tissue edema has resolved, indicated by the appearance of wrinkles and epithelialized blisters. In the author's experience, most tibial pilon fractures are suitable for tibial ORIF within 14 days. Fractures beyond three weeks from injury become increasingly difficult to manipulate, and the necessary fragment mobilization can lead to significant fragment devitalization. In rare cases where the soft tissue envelope never reaches a safe point for surgical approaches, the author opts for definitive external fixation for the duration of treatment.

Careful review of axial, sagittal, and coronal CT scan images is crucial to understand the articular injury. Key factors include the location of comminution and impaction, and how the articular fragments relate to the metadiaphysis. Initial assessments focus on the position, size, and relationship of the Volkmann fragment to the fibula, the tibia, and the rest of the articular surface. This helps determine the best surgical approach, typically between an anterolateral or anteromedial exposure. Valgus or abduction injuries with anterolateral plafond comminution and/or impaction, without medial articular plafond comminution, are best suited for anterolateral exposure. Increasing medial plafond comminution and varus or adduction injuries indicate an anteromedial exposure. Supplemental posteromedial or medial malleolar- type exposures can be used alongside the anterolateral approach to manage medial malleolar or medial metaphyseal fractures.

Posterior approaches, like posterolateral and posteromedial, are helpful for reducing and directly fixing displaced posterior articular fragments, but they involve additional dissection, which may increase the risk of nonunion due to fracture fragment devitalization [68]. Anterolateral and anteromedial incisions allow satisfactory visualization of the joint surface and metaepiphyseal fracture lines, with proximal plate fixation often performed percutaneously.

Articular surface reduction employs all techniques, including anatomical reduction of available cortical interdigitations, direct visualization of the articular surface, and fluoroscopic confirmation. A common sequence involves the accurate reduction of the posterolateral Volkmann fragment relative to the fibula, correction of any dorsiflexion impaction of the articular surface, and reduction of the Volkmann fragment to the medial malleolar fragment along the posteromedial fracture line. Central plafond comminution is then reduced, and bone graft, if needed, is applied. The anterolateral Chaput fragment is subsequently reduced.

Provisional fixation is achieved using liberal use of K-wires, small diameter, and occasionally mini-fragment screw/plate devices. The external fixator provides distraction and allows visualization of the articular surface, maintaining the talus in a slightly posterior, distracted, and plantarflexed position. After reduction and provisional fixation of the articular surface, the external fixator's modularity allows it to indirectly reduce axial metadiaphyseal alignment if necessary. Distraction can be reduced to more accurately align the metadiaphyseal fracture, held provisionally with the external fixator.

The choice of implant depends on its specific role. Coronal plane articular fracture lines are best secured with anterior-posterior fixation, while sagittal plane articular fracture lines are secured from medial to lateral. Valgus injuries often require stiffer lateral buttress implants, and the reverse is true for varus or adduction injuries. Significant metadiaphyseal injuries require stiff lateral (typically anterolateral, but occasionally posterolateral) and medial implants. Occasionally, morselized allograft bone graft is needed to fill epiphyseal bone voids to support articular surface fragmentation.

The wounds are closed in layers with monofilament absorbable sutures for the deep layers and nylon-modified Allgower-Donati sutures for the skin. Patients are typically placed in a below-knee splint with the foot in a neutral plantigrade position. Postoperative pain control is facilitated by a sciatic and femoral nerve block performed at the end of the surgical procedure. The previously outlined postoperative care plan is followed.

INTRA OPERATIVE IMAGES AND POST OPERATIVE XRAYS

Fig 9: figure showing lateral aspect of leg with bone outline

Fig 10: anterolateral approach – deep dissection

Fig 11: ORIF fibula with tubular plate

Fig 12: provisional fixation of fracture fragments with k wire

Fig 13: immediate postoperative Xray

Fig 14: postoperative Xray at 6 months

RELEVANCE

The Management of tibial pilon fractures have always been perplexing. It is very difficult to attain a good functional outcome owing to the complex fractures and the soft tissue injury that often accompanies the fracture. Many modalities have been tried in past such as immediate fixation, external fixation alone, delayed fixation and so on to arrive at the best management option. Pilon fracture is usually seen in high energy trauma and its incidence is increasing due to the hike on the number of road traffic accidents. Other mechanism include fall from height, sports injuries and slip and fall. The fracture needs a CT imaging to understand the fracture pattern and the fragments involved which in turn determines the surgical approach. In grossly communited fractures with significant soft tissue compromise, an external fixator is applied initially with or without fibular fracture fixation if needed and ORIF is done as a second stage procedure once the soft tissue status improves using an anterolateral distal tibial plate. Hence this thesis is relevant to understand the superiority or inferiority of delayed anterolateral plating with regards to management of tibial pilon fractures and to understand the functional outcome delayed anterolateral plating in tibial pilon fractures.

METHODOLOGY

STUDY DESIGN:

Observational study

STUDY SETTING:

Department of Orthopedics, Government Medical College, Thiruvananthapuram

STUDY PERIOD:

For a period of one year after approval of institutional ethics committee

STUDY POPULATION:

Patients sustaining tibial pilon fractures attending Government Medical College, Thiruvananthapuram

STUDY SUBJECTS:

Patients sustaining tibial pilon fracture attending Government Medical College, Thiruvananthapuram undergoing anterolateral plating once the limb edema subsides.

INCLUSION CRITERIA:

Patients visiting the Orthopedic department with tibial pilon fractures above the age of 18 years

EXCLUSION CRITERIA:

Patients not willing for surgery

SAMPLE SIZE:

$n = (Z_{1-\alpha/2})^2 * P*Q / d^2$

where $z_{1-\alpha/2}$ = 1.96 at 5% level of significance

p = proportion of patients with good functional outcome = 80% [69]

q =100- p = 20%

d = relative precision = 15% of p = 12 n = 1.96*1.96*80*20/ 144= 42

STUDY VARIABLES

1. Age
2. Sex
3. Comorbidities:

a. Diabetic Status

b. Obesity

c. Anaemia

d. Occlusive vascular diseases

e. Neuropathic conditions

SAMPLING TECHNIQUE:

Patients attending Orthopaedic department meeting the eligible criteria and giving consent will be consecutively selected for the study till the sample size is attained.

DATA COLLECTION TOOL AND DATA COLLECTION TECHNIQUE:

After obtaining institutional ethics committee clearance, informed consent will be obtained from each study participant, who satisfy the inclusion criteria. Patients will be admitted fracture will be immobilized with plaster of Paris slab or external fixator, once edema subsides, they will be posted for open reduction and internal fixation. A pretested questionnaire will be given to them on admission to assess the study variables. Post operatively they will be given in patient care and discharged; routine follow-up will be done. Patient will be called upon for evaluation of functional outcome at 6 months and assessed with kaikkonen ankle score and results will be categorized

DATA ANALYSIS

Data will be entered into excel sheets.

Analysis of data will be done using SPSS Version 27 statistical software.

Quantitative variables will be expressed as mean and standard deviation and qualitative variables will be expressed as proportions. Association of quantitative variables will be determined using t test and that of qualitative variables using chi square test.
Significance level of 95% confidence interval will be determined for all analysis.

ETHICAL CONSIDERATIONS

Institutional ethics committee clearance will be obtained. Permission letter will be obtained from the relevant department.
Confidentiality will be ensured and maintained throughout the study. Informed written consent will be taken prior to inclusion in the study. No cost shall be incurred from any of the participants.
Study results will be used only for scientific purpose and publications.

MANAGEMENT AND ANALYSIS

The data collected were checked by the guide periodically under his guidance necessary corrections were done. Data collected were entered into the excel sheet and analyzed using SPSS software. Outcome of the subjects were analyzed with the clinical and functional aspects and indices calculated. In addition to the descriptive statistics appropriate tests were applied accordingly to determine statistically significant differences. Data collected and tabulated were scored by kaikkonen ankle score.

MANAGEMENT OF PATIENT

Upon arrival of the patient trauma survey was carried out giving emphasis to airway breathing and circulation. Vitals were monitored. Complete skeletal survey was then carried out to rule out any associated fractures. Patient was also surveyed for injury to head chest abdomen spine and pelvis. Neurovascular examination was also done and the affected limb was immobilized with plaster and the patient was send to radiology.

PRE-OPERATIVE ASSESSMENT

At the time of admission all the pre operative investigations were done and screened for any derangements, Anaesthesia consultation was carried out and their orders followed up. After optimizing medical comorbidities and getting anaesthesia fitness patients were posted for fixation. CT scans were taken and the fractures were analyzed in depth. The fragments to be fixed were identified and appropriate approach was planned. Preoperative planning was also done to assess the soft tissue status of the limb and the fracture pattern and fragments to be fixed. Decision was taken on the operability of the limb, those patients with relatively better soft tissue status were continued on plaster immobilization, those with bad soft tissue were planned for temporary external fixation and delayed ORIF.

SURGICAL PROCEDURE

Based on the clinical and radiological assessment patients with bad soft tissue profile are planned for triangular frame external fixation of ankle. Patients are generally given spinal anaesthesia and positioned supine. After scrubbing, painting and draping, tibial Schantz pins are placed followed by the calcaneal pin. A 3.5 Schantz pin is placed on the first metatarsal head. The frame is connected with clamps and rods and the appropriate distraction is provided under fluoroscopic guidance. Once the soft tissue becomes viable for definitive fixation and in those patients who were managed initially with plaster immobilization owing to the acceptable soft tissue status, patients are taken up for definitive fixation. Procedure is usually done under spinal anaesthesia. Anterolateral approach is the preferred first approach in our institution through which initially the fibular fixation is done if there is a concomitant fibular fracture, once the plafond is visualized reduction of the fragments is done and they are provisionally fixed with k wires. Definitive fixation is then carried out using an appropriate implant usually the anterolateral plate. A communited fracture may require an additional posteromedial or posterolateral approach and fixation of fragments with appropriate implants. The wound is then closed in layers over a drain and a below knee slab is given for immobilization.

POST OPERATIVE PROTOCOL

Post operatively patients were send to the post operative ward where vitals were recorded. A post operative hemoglobin value below 9gn/dl warranted blood transfusion. Patients were given IV antibiotics till post operative day 5 and then bridged to oral antibiotics till suture removal. Analgesics were modified depending on the patient's pain tolerance and demands. Sutures were removed on post operative day 14 or later.

DISCHARGE

The patients were discharged to home after subsequent post operative dressings, making sure that the wounds were healing and the general condition of the patients was ensued to be stable.

KAIKKONEN FUNCTIONAL SCALE [70]	
1. Do you have any of the following symptoms during activity? Pain, swelling, stiffness, tenderness, or giving way?	
No symptoms of any kind	
15	
Mild symptoms (only one of these symptoms is present)	
10	
Moderate symptoms (two or three of these symptoms are present)	5
Severe symptoms (four or more of these symptoms are present)	0
2. Can you walk normally?	
Yes	
15	
No	
0	
3. Can you run normally?	
Yes	
10	
No	0

4. Walking down the stairs	
Under 13,5 seconds	10
13.5-15 seconds	5
Over 15 seconds	0
5. Rising on heels with the injured leg	
Over 40 times	
10	
30-39 times	5
Under 30 times	0
6. Rising on toes with the injured leg	
Over 40 times	10
30-39 times	5
Under 30 times	0
7. Single limbed stance with the injured leg	

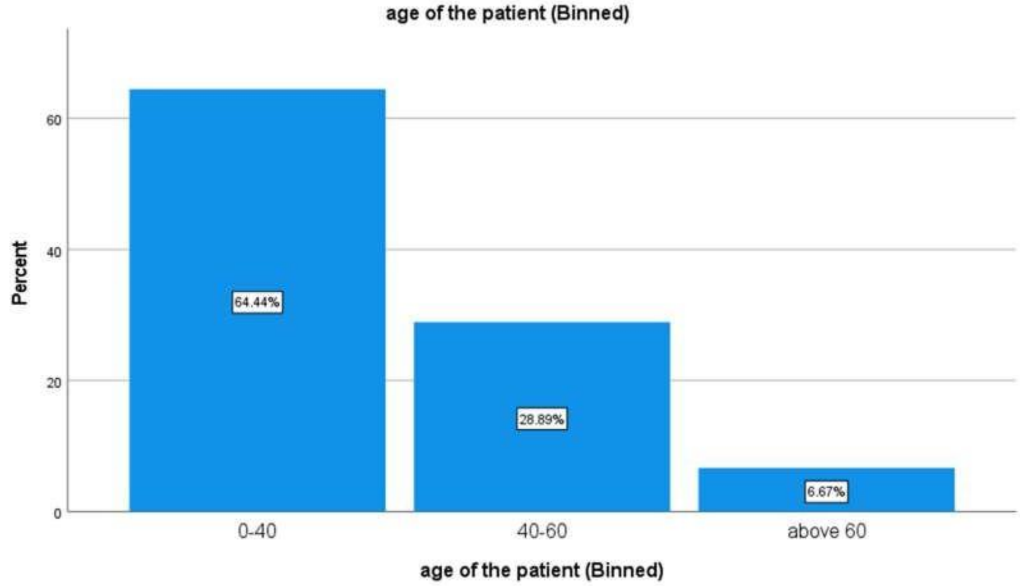
Over 55 seconds 10
50-55 seconds 5
Under 50 seconds 0
8. Laxity of the ankle joint (Clinical Anterior Drawer Sign [ADS])
Stable (< or = 5 mm) 10
Moderate instability (6-10 mm) 5
Severe instability (10 mm) 0
9. Dorsiflexion range of motion (non-weight bearing with a goniometer)
> or = 10 degrees 10
5-9 degrees 5
<5 degree0

OBSERVATION AND RESULTS

Table 1: Age group affected

age of the patient		
	N	%
0-40	29	64.4%
40-60	13	28.9%
above 60	3	6.7%

Fig15: Age group affected

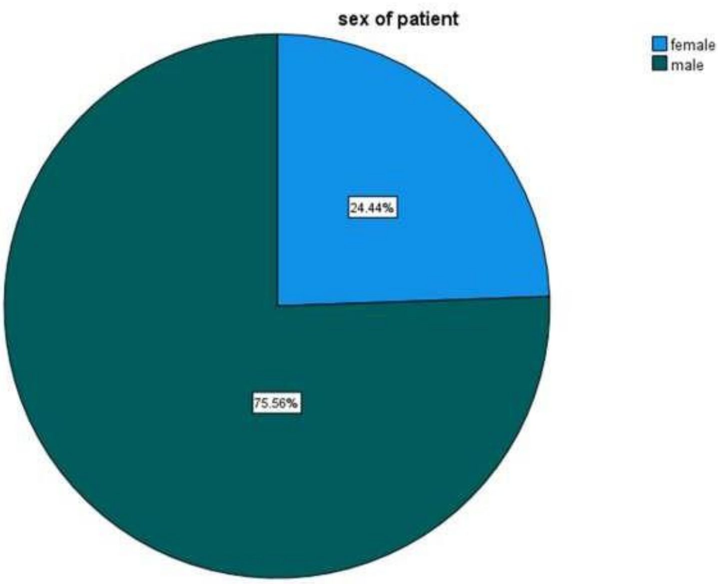


The mean age of our 45 patients was 38.53 (19- 72). 29 among 45 fell in the age category of less than 40 years

Table 2: Sex Predilection

Sex of the patient		
	N	%
female	11	24.4%
male	34	75.6%

Fig16: Sex Predilection

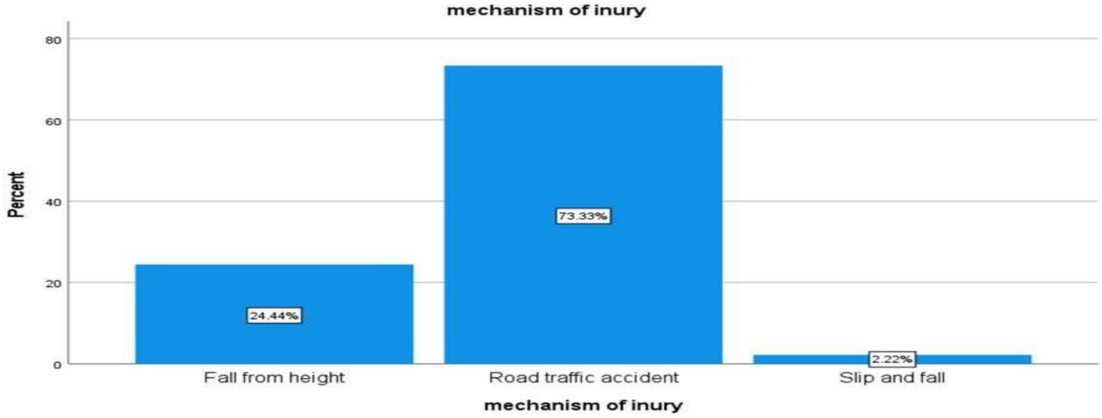


The sex distribution in our study was 75.6% males and 24.4% females

Table 3: Mode of traum

Mechanism of injury		
	N	%
Fall from height	11	24.4%
Road traffic accident	33	73.3%
Slip and fall	1	2.2%

Fig17: Mode of trauma

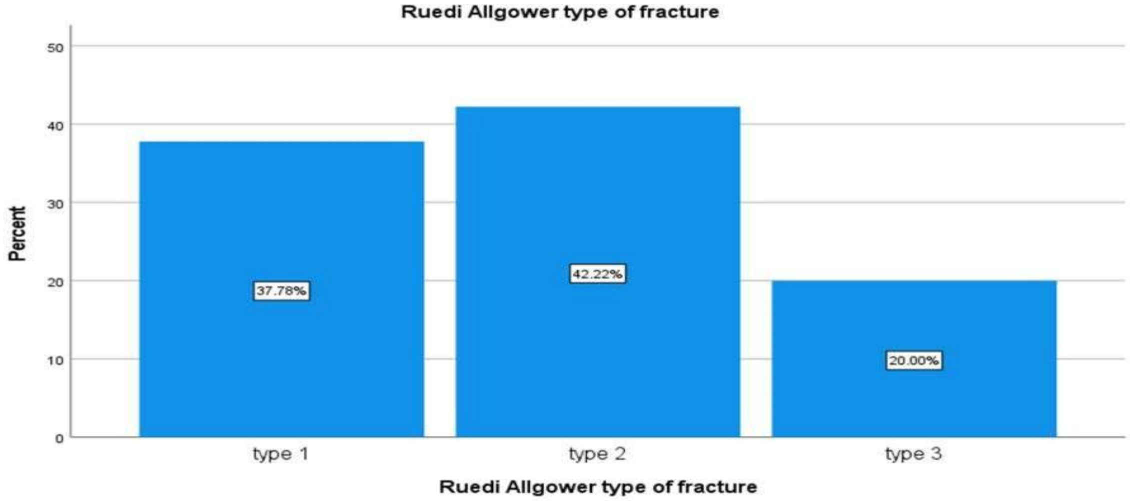


In our study 24.4% had injury due to fall from height, 73.3% due to road traffic accident and 2.2% due to slip and fall

Table 4: Ruedi Allgower classification of fracture

Ruedi Allgower type of fracture		
	N	%
type 1	17	37.8%
type 2	19	42.2%
type 3	9	20.0%

Fig18: Ruedi Allgower type of fracture

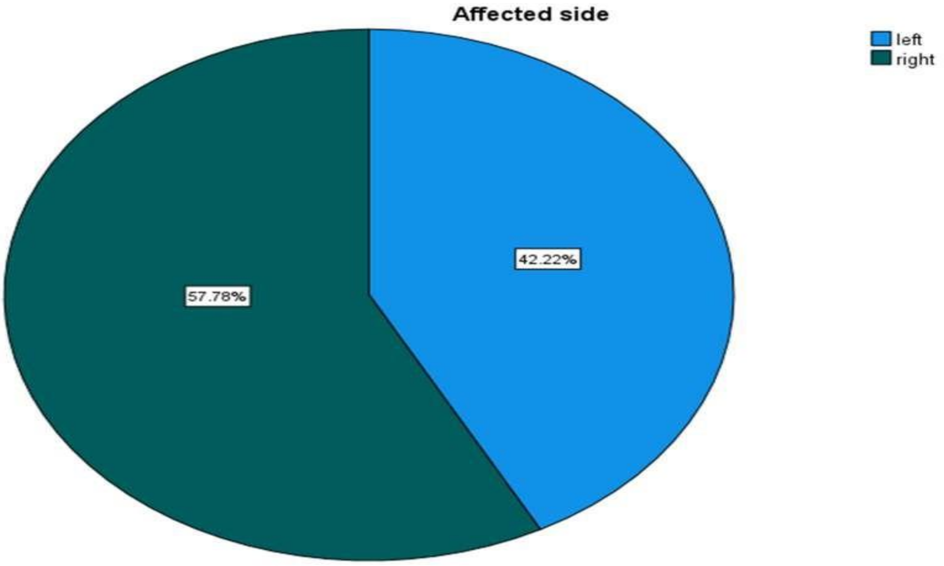


37.8% of our patients had ruedi allgower type 1 fracture, 42.2% has type 2 and 20% had type 3 fracture.

Table 5: Side affected

Affected side		
	N	%
Left	19	42.2%
Right	26	57.8%

Fig19: Side predominance

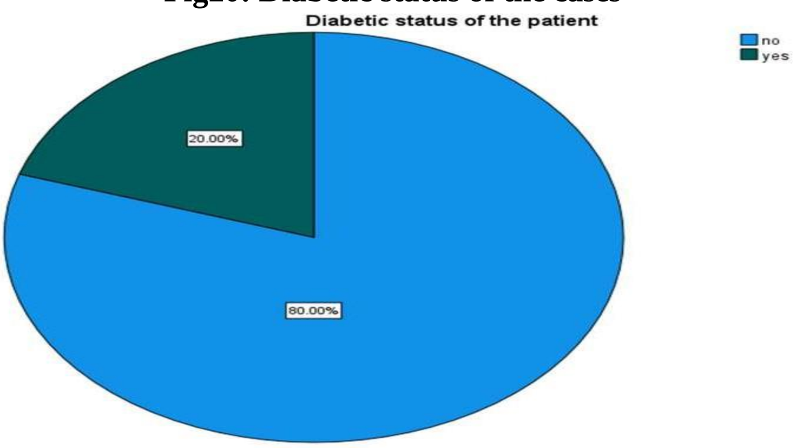


Right side was injured in 57.8 % of cases and left side had trauma in 42.2% cases

Table 6: Diabetic status of the cases

Diabetic status of the patient		
	N	%
Not diabetic	36	80.0%
Diabetic	9	20.0%

Fig20: Diabetic status of the cases

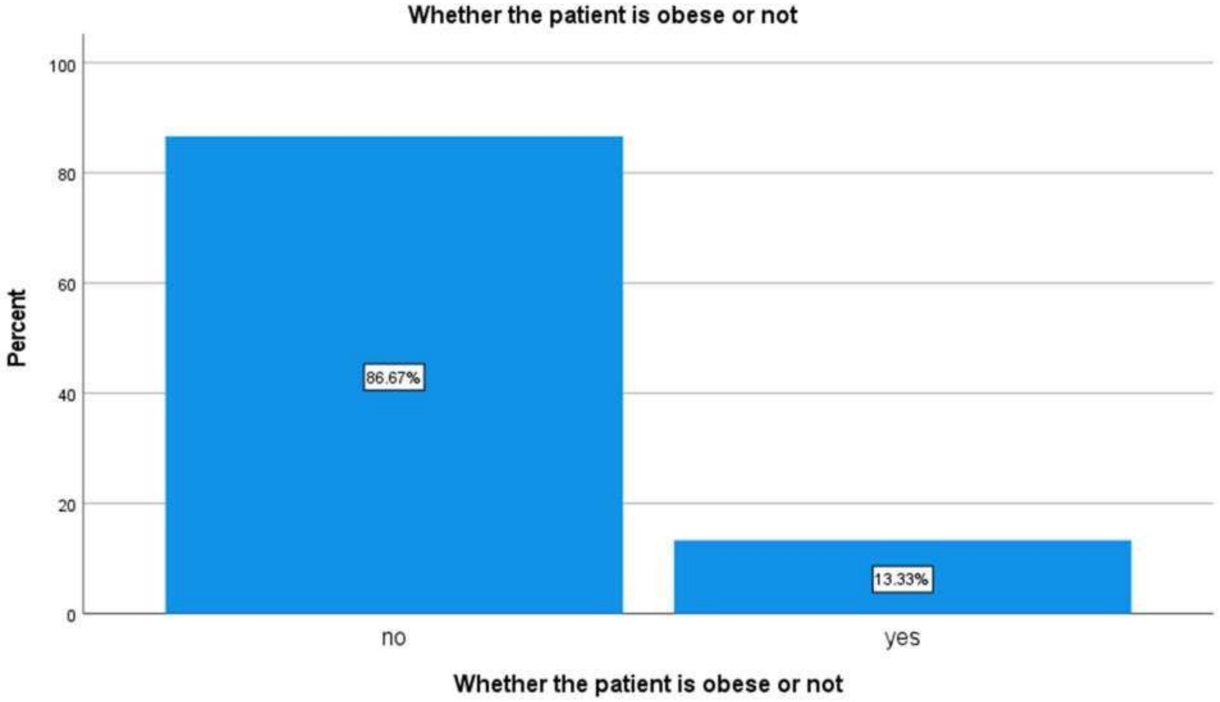


80% of our patients were not diabetic while 20% were diabetic

Table 7: Whether the patient is obese or not

Whether the patient is obese or not		
	N	%
no	39	86.7%
yes	6	13.3%

Fig21: Whether the patient is obese or not

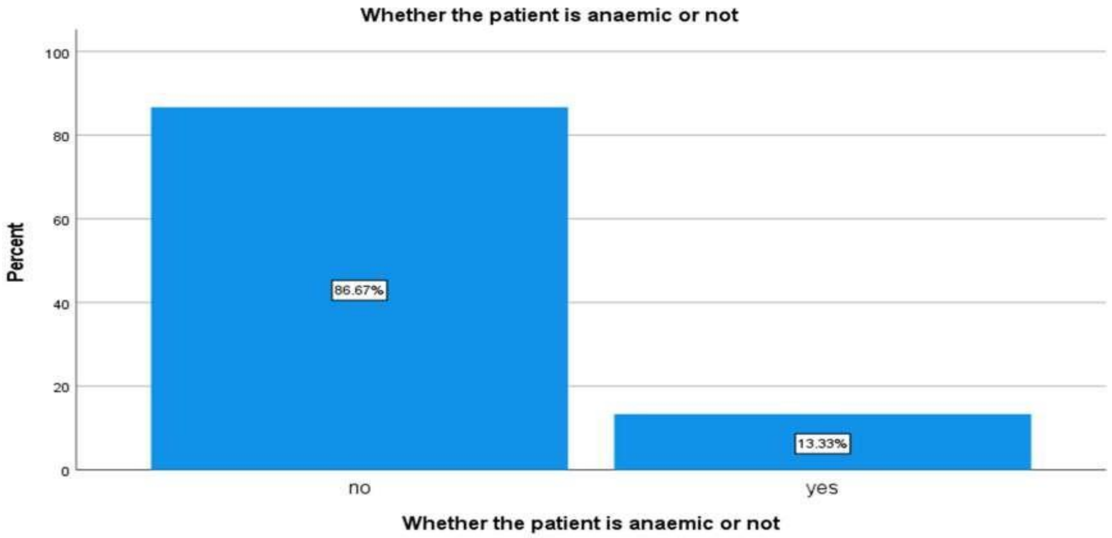


Of the 45 patients 6 (13.33%) of them were obese as per the WHO classification of obesity that is BMI more than 30

Table 8: Whether the patient is anaemic or not

Whether the patient is anaemic or not		
	N	%
no	39	86.7%
yes	6	13.3%

Fig22: Whether the patient is anaemic or not

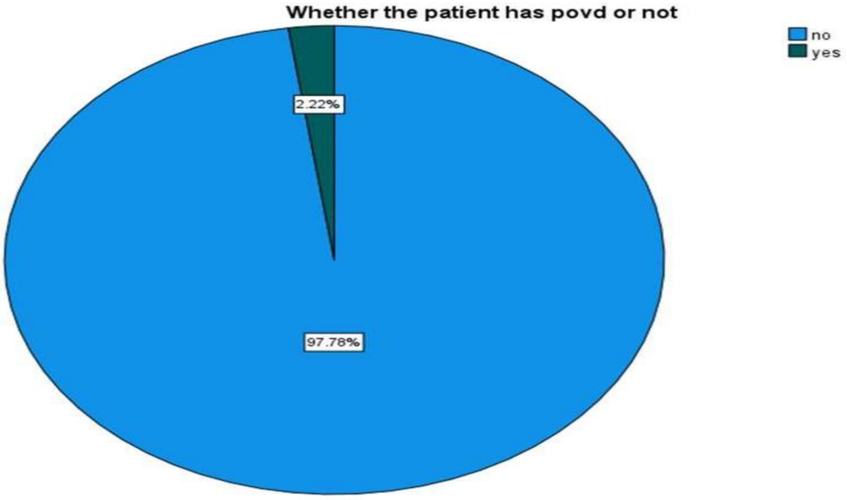


Of the 45 patients 6 (13.33%) of them were anaemic as per the WHO classification that is hemoglobin less than 13 in males and less than 12 in non-pregnant females

Table 9: Whether the patient has povd or not

Whether the patient has povd or not		
	N	%
no	44	97.8%
yes	1	2.2%

Fig23: Whether the patient has povd or not



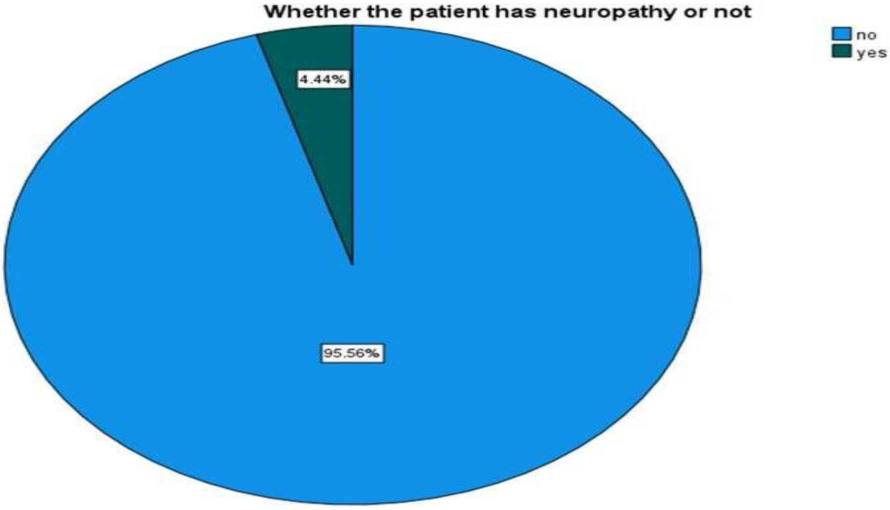
Of the 45 patients only 1 patient (2.22%) had povd

Table 10: Whether the patient has neuropathy or not

Whether the patient has neuropathy or not		
	N	%
no	43	95.6%
yes	2	4.4%

.

Fig24: Whether the patient has neuropathy or not

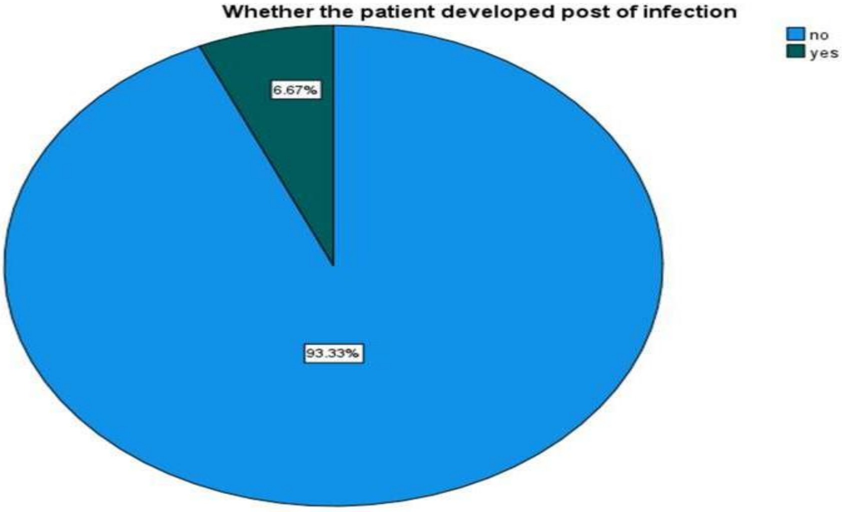


2 patients out of 45 patients (4.44%) had neuropathy secondary to diabetes

Table 11: Whether the patient had infection in post operative period or not

Whether the patient developed post of infection or not		
	N	%
No	42	93.3%
Yes	3	6.7%

Fig25: Whether the patient had infection in the post operative period or not

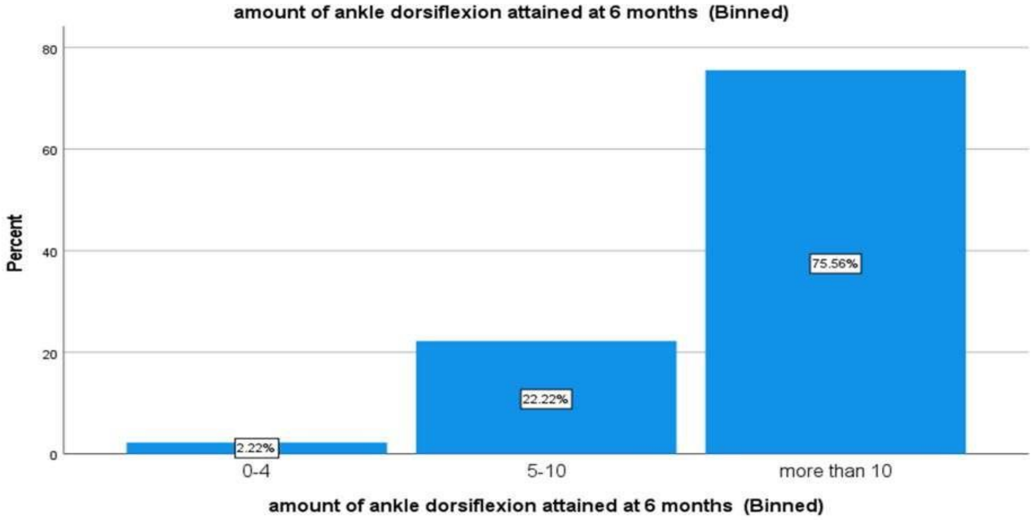


On follow up we found out that 3 out of 45 patients (6.7%) developed surgical site infection

Table 12: Amount of dorsiflexion attained at the follow up of 6 months

Amount of ankle dorsiflexion attained at 6 months in degrees		
	N	%
0-4	1	2.2%
5-10	10	22.2%
more than 10	34	75.6%

Fig26: Amount of dorsiflexion attained at the follow up of 6 months

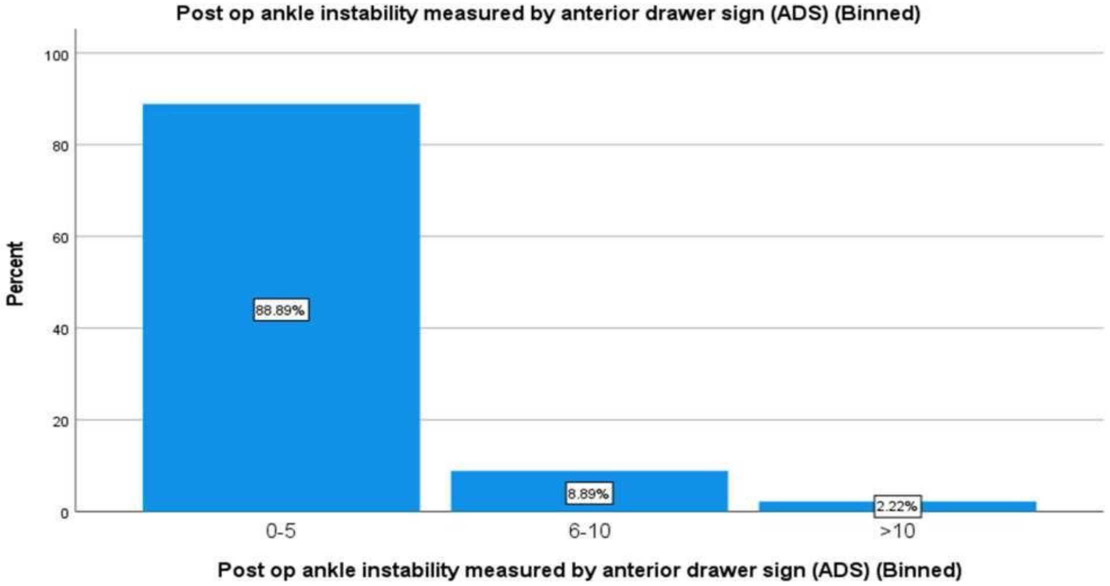


Amount of dorsiflexion attained at the follow up of 6 months was assessed and estimated that 75.6% had dorsiflexion above 10 degrees, 22.22% had dorsiflexion in the range of 5-10 degrees while 2.22% had below 5 degrees of dorsiflexion.

Table 13: Post op ankle stability measured by anterior drawer sign (ADS)

Post op ankle stability measured by anterior drawer sign (ADS)		
	N	%
less than 5mm	40	88.9%
6-10mm	4	8.9%
more than 10mm	1	2.2%

Fig27: Post op ankle stability measured by anterior drawer sign (ADS)



Measure of ankle stability at the follow-up of 6 months was measured by anterior drawer sign, 88.89% patients had less than 5mm translation, 8.89% had a translation of 5-10mm and 2.22% had a gross instability of more than 10mm translation. The mean value of ankle translation was 2.07 with standard deviation of 2.934

Table 13: Post operative kaikkonen ankle score at 6 months post op

Post op kaikkonen ankle score at 6 months follow up		
	N	%
Poor	1	2.2%
Fair	4	8.9%
Good	23	51.1%
Excellent	17	37.8%

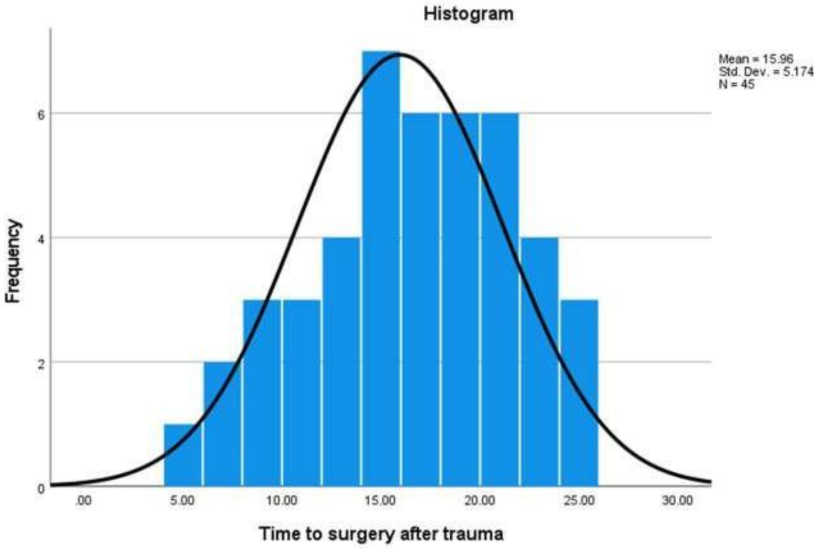
Fig28: Post operative kaikkonen ankle score at 6 months post op

Kaikkonen ankle score of all the subjects were calculated at the follow-up of 6 months after surgery revealing 17 out of 45 (37.78%) had excellent functional outcome, 23 out of 45 (51.11%) had good functional outcome, 4 out of 45(8.89%) had fair and 1 out of 45 (2.22%) had poor functional outcome. 40 out of 45 patients (88.89%) had good and above functional outcome.

Table 14: TIME TO SURGERY AFTER TRAUMA

FREQUENCYY TABLE		
TIME TO SURGERY AFTER TRAUMA		
N	Valid	45
	Missing	0
Mean		15.9556
Median		16.0000
Std. Deviation		5.17404

Fig29: Histogram showing time to surgery after trauma with normal curve



The earliest intervention was done at 5 days and the farthest at 25 days with a mean delay of 15.9 days with a standard deviation of 5.17 days

RESULTS

1. A total of 88.9% of patients had good and above functional outcome where as 11.1% had below good functional outcome. Out of this 100% of type 1 ruedi Allgower fractures had good and above functional outcome, 94.7% of type 2 ruedi Allgower fractures had good and above functional outcome and only 55.6% of type 3 fractures had good and above functional outcome and the finding was statistically significant (p value of .004 by fisher exact test), indicating that type 1 fractures have better functional outcome than type 2 better than type 3
2. 20% of the total patients were diabetic and 33.3% of diabetic patients had below good functional outcome, among non-diabetic patients 94.4 % had good and above functional outcome. This difference was statistically significant with a p value of .047 by fisher exact test
3. 6.7% of total patients had post operative wound infection of which 66.7% had below good functional outcome while only 7.1% of patients without infection had below good functional outcome. This difference was statistically significant with a p value of .029 by fisher exact test
4. On assessing the relationship between age category and the functional outcome 93.1% of patients of age group 0-40 years had good and above functional outcome, 86.6% of patients of the age group 40-60 years had the same and only 66.7% of patients above 60 years had good or above functional outcome. However, this was not statistically significant
5. On comparing the mean kaikkonen score among males and females using independent t test it was found out that males had a mean score of 77.06 with standard deviation 11.489 and females had a mean sore of 72.73 with a standard deviation of 10.808. however, this difference was not statistically significant. (p value of 0.277)
6. On assessing the relationship between diabetic status and post operative infection rate it was found out that 6.7% of total patients had post operative infection of which only 33.3% were diabetic patients and 66.7% were not diabetic. The difference was not statistically significant (p value 0.497 by fisher exact test)

DISCUSSION

The mean age of our 45 patients was 38.53 (19- 72). 29 patients of the 45 belonged to the age group of less than 40 years. The age distribution is similar to the studies by other researchers such as Manoj Das et al mean age of 41.4 years (SD±14.36) [71] .There was a male preponderance of 76.5% as opposed to 90% i8n the above study. Vikram et al. [72] in their study attributes 70 % of the injuries to road traffic accidents and 65% right side affection and in our study 24.4% had injury due to fall from height, 73.3% due to road traffic accident and 2.2% due to slip and fall. Right side was affected in 52.78% and left side in 42.22% of our patients.

Howard et al reported 2 (5.1%) wound healing complications in a study among 39 patients who were managed by anterolateral approaches for addressing tibial pilon fractures [73]. Our study revealed the fact that 3 out of 45 patients (6.7%) developed surgical site infection.

At an average 13.7-months follow-up, Grose et al reported that the total ankle range of motion arc measured 43º (range, 15º-70º [57]. The maximum ankle dorsiflexion averaged 10º, and the maximum plantar flexion averaged 35º. A comparable result was obtained in our evaluation where the Amount of dorsiflexion attained on follow-up was assessed and concluded that 75.6% had dorsiflexion above 10 degrees, 22.22% had dorsiflexion in the range of 5-10 degrees while 2.22% had dorsiflexion short of 5 degrees.

A. Dhar et al. gives functional outcome was assessed using Kaikkonen Ankle Scores with average score being 74.25). Excellent outcome was found in 20% cases, good in 60% cases, fair results in 15% cases and poor outcome was in one patient (5%) [69]. In our study Kaikkonen ankle score of all the patients were calculated at 6 months after surgery and revealed that 17 out of 45 (37.78%) had excellent functional outcome, 23 out of 45
(51.11%) had good functional outcome, 4 out of 45(8.89%) had fair and 1 out of 45 (2.22%) had poor functional outcome. 40 out of 45 patients (88.89%) had good and above functional outcome. They had a mean delay of 21 days till the patient was fit for surgery. The mean time to surgery after trauma in our study was 15.9days with SD of 5.17 37.8% of our patients had ruedi allgower type 1 fracture, 42.2% has type 2 and 20% had type 3 fracture. 100% of type 1 ruedi Allgower fractures had good and above functional outcome, 94.7% of type 2 ruedi Allgower fractures had good and above functional outcome and only 55.6% of type 3 fractures had good and above functional outcome and the finding was statistically significant (p value of .004 by fisher exact test), indicating that type 1 fractures have better functional outcome than type 2 better than type 3

Non diabetic patients had statistically significant better functional outcome 94.4% as opposed to diabetic patients with only 66.7% good functional outcome among diabetic patients. Diabetes as such had no significant relation with wound infection however functional outcome of infected cases were significantly poorer as compared to non-infected cases

CONCLUSION

Pilon fracture is caused by high energy trauma to the ankle, most commonly seen in road traffic accidents. The condition of soft tissue is equally important as the fracture pattern in determining the functional outcome of the patient.

There was a better functional outcome with ruedi allgower type 1 relative to type 2 and 3. Good and above functional outcome was obtained in 88.89% of patients with delayed anterolateral plating.

There was a mean delay of about 16 days in fixing the fractures owing to the poor soft tissue condition.

There was a 6.7% of post operative infection rate and the infected cases had a significantly poorer

functional outcome.
Hence delayed anterolateral plating greatly improves the functional outcome in tibial Pilon fractures

LIMITATIONS

1. The sample size of our survey was small
2. This was an institutional study and a multicentric study may yield a better result
3. The study was done over a duration of just 1 year
4. Further follow up could help us to asses any improvement in functional outcome.

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