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ORIGINAL ARTICLE

The outcome of pilon fracture management using different fixation modalities

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ABSTRACT

Keywords: Pilon fracture, Open reduction, and internal fixation, Ilizarov, Delta frame fixator.

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Background: treatment of pilon fractures is challenging and the appropriate method is still uncertain. **Purpose**: detection of the best modality for the treatment of pilon fractures. **Patients and Methods**: This prospective study was conducted on 40 patients with pilon fractures. The patients were subdivided into 3 groups; Group A: 12 patients underwent temporary DFF followed by later ORIF, and Group B: 8 patients underwent fixation with primary IF. Group C: 20 patients underwent fixation with Primary ORIF. **Results :**The adequacy of anatomical reduction was significantly higher in group C than in groups A and B. The union rate was 97.5%. In group C, 1 (5%) case of late postoperative infection, 2 (10%) cases of skin breakdown, and 5 (25%) cases of ankle stiffness. AOFAS was significantly excellent in group C than in group A with no significant difference between groups A, B, and B, C. **Conclusion:** using the primary Ilizarov fixator is the best treatment for all open and closed type RA III pilon fractures. It is more successful than primary ORIF surgery. primary ORIF is the ideal option for closed pilon fracture RA I and II with mild oedema. Using temporary DFF followed by later ORIF is reliable technique for open fracture RA I and III.

INTRODUCTION

The tibial plafond fractures account for 1-10 % of fractures of the lower limb and 5-7% of tibial fractures. (1) The term "pilon" refers to tibial plafond explosion injuries that occur when the tibia is subjected to axial compression forces, where the talus acts as a pestle that is directed vertically, destroying the metaphyseal and articular portions of the tibial plafond. (2) The high-energy trauma is the main cause of these serious fractures which are often characterized by different degrees of bone comminution and displacement and soft tissue damage. (3, 4) The most reliable classification systems of the pilon fractures are the Rüedi and Allgöwer and AO/OTA, regards the amounts of comminution and displacement of the articular surface. (5, 6) An axial CT scan was used by Topliss to identify the six typical fragments: anterolateral, posterolateral, anterior, posterior, medial, and central die-punch fragments. (7) The closed soft tissue damage and open fractures are classified according to Tscherne and Goetzen, and Gustilo-Anderson (OG) respectively. (8, 9) The target of pilon fracture management, is the restoration of the normal anatomy of the articular surface and ankle joint mechanical axes through a stable fixation technique allowing early ankle joint range of motion (ROM). (10, 11) Different Modalities were described for surgical management of pilon fractures; (a) primary Ilizarov fixator (IF), (b) primary open reduction and internal fixation (ORIF), (c) temporary external delta frame fixator (DFF) followed by delayed ORIF. (12) Using external fixation depends on the capsuloligamentotaxis theory through tightening the soft tissues of the ankle joint but is associated with disadvantages such as patient noncompliance, pin tract infection, and development of osteomyelitis. (13, 14) Primary ORIF achieves anatomical reduction for metaphyseal and articular components of the tibial plafond fractures but it is associated with complications such as skin breakdown, infection, and non-union. (15,16), this made the surgeons perform two steps technique: temporary external fixator, followed by ORIF when the soft tissue condition is improved. (17-19) This study aimed to evaluate the best modality of pilon fracture fixation as regards: union rate, skin complications, and final function outcome.

PATIENTS AND METHODS

This is a prospective cohort design to investigate the outcomes of the management of pilon fractures using different fixation modalities. A consecutive sample of 40 patients diagnosed with pilon fractures was recruited from the orthopedic department, of Aswan University Hospital between February 2021 to January 2022.

Inclusion criteria: (a) age of patients between 18 and 70 years, (b) recent fractures; within 48 hours, and (c) closed fractures or open fractures Gustilo I, II, and III A. Exclusion criteria: (a) age less than 18 or more than 70 years, (b) polytraumatized patients, (c) associated proximal tibial or calcaneus fractures, (d) open fractures Gustilo III B and C, (e) peripheral vascular diseases, (f) uncontrolled diabetics, (g) immunocompromised patients, and (h) morbid obesity.

Eligible individuals were approached, provided with detailed information about the study, and enrolled after obtaining their Written informed consent. The cohort was followed prospectively throughout their treatment and postoperative course.

Pre-operative evaluation: Detailed history, Physical examination: General: A primary survey according to advanced trauma life support (ATLS) protocol. Local: X-ray radiographs of the ankle (AP, lateral, and Mortise views), and assessment of foot vascularity. Pre-operative ankle 3D CT was performed for all patients.

This study was conducted by the principles outlined in the Declaration of Helsinki. Ethical approval was obtained from the Institutional Review Board at the Faculty of Medicine, Aswan University.

Surgical techniques: The patients were classified according to the method of fixations into Group A: 12 patients underwent temporary DFF followed by ORIF, Group B: 8 patients underwent primary IF. Group C: 20 patients underwent Primary ORIF.

Group A is performed in patients with open (OG I, and II) or closed fractures with severe soft tissue oedema (blisters). Group B was performed in all patients with OG IIIA fractures. Group C was performed in patients with closed fractures with mild oedema. All operations were performed under spinal anesthesia on radiolucent tables. The fixation started with fibular fracture fixation with ORIF or percutaneous intramedullary k wire.

Temporary Delta Frame external fixator (DFF) then later ORIF (Group A)**:** A triangular joint-spanning external fixation device consists of a Steinmann pin or threaded pin passing transversely from medial to lateral through the posterior part of the calcaneus (tuberosity), and 2 – 3 Schanz screw fixed to the tibial shaft in the sagittal plane from the medial side faraway proximal to the fracture site then a connection between each end of the Steinmann pin and the

Schanz screw in a triangular fashion, tightened rod clamps secure the connection. The longitudinal rods are connected with short transverse rods to add frame stability. The reduction is done by manipulating the calcaneus with the Steinmann pin with axial traction and using the reduction-pointed bony clamp to the displaced bony fragment. After achieving the accepted alignment confirmed with the image intensifier, the rod pin clamp is tightened. (Figure, 1). The rotation of the foot is controlled through the extension of the fixation distally with 2 Schanz screws one fixed to the base of the 5th and the other to the base of the 1st metatarsal. Partially threatened 3.5mm screws may use to fixation of the reducible sizable fragments of the distal tibia as a hybrid fixation. This device extends between the foot and the tibia spanning the ankle and the fracture area to indirectly reduce the fracture through capsuloligamentotaxis. The DFF acts as a temporary fixation to enable healing of the soft-tissue damage and then shifts to ORIF.

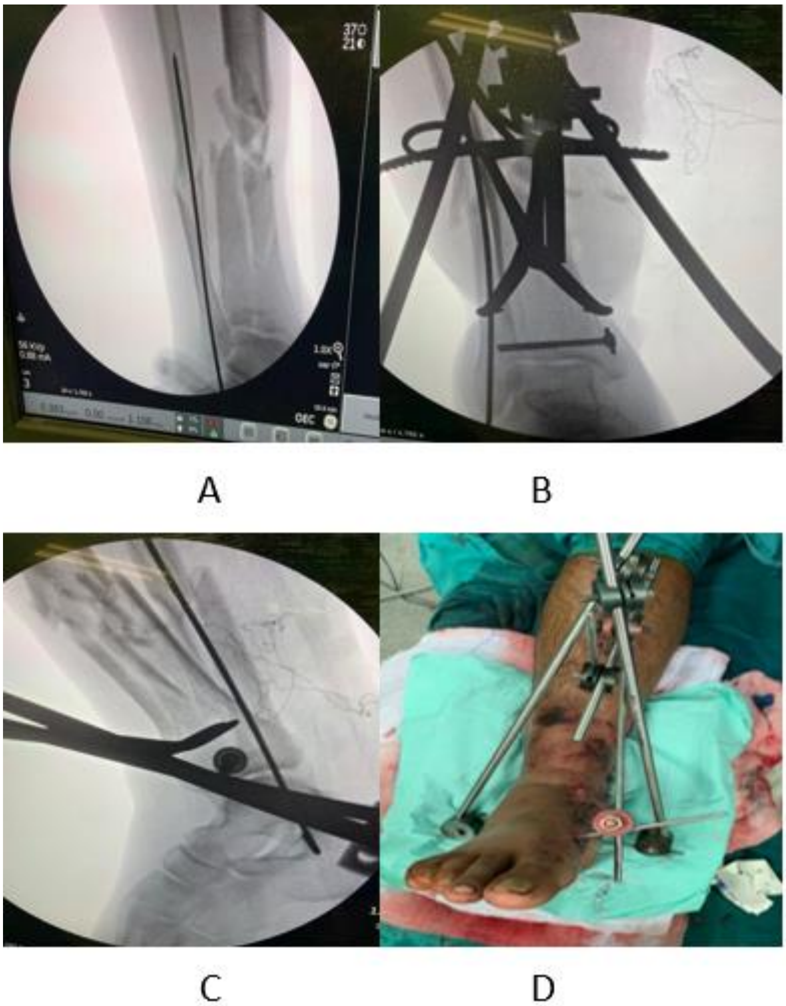

Figure 1: 36-year-old male patient with pilon fracture type C. (A) C- arm image shown fixation of fracture fibula with intramedullary k wire, (B and C) C- arm image shown using reduction pointed clamp and interfragmental lag screw for reduction of fracture fragments. (D) clinical photos to show of the DFF.

One-stage fixation with IF (Group B): The Ilizarov device was composed of three connected rings arranged as follows; two rings fixed to the distal half of the tibia proximal to the fracture and a third ring fixed as distally as possible at the level of tibial plafond. The main bone pieces were reduced and fixed using 1.8 mm olive wires that were securely fastened to the rings. By distraction of the fracture site with the Ilizarov device, smaller fragments of bone can be reduced and stabilized through ligamentotaxis. Moreover, valgus and varus deformities of the ankle are prevented by controlling the limb's alignment with the Ilizarov device. Additional calcaneal half ring fixed by two Schanz screw the calcaneus and connected to the other rings to spanning of the ankle and stabilize the frame in cases of severe comminution. Image intensifier controls the accuracy of reduction. 4-6 weeks after surgery, early mobilization was initiated using ankle joint hinges**.**

One-stage fixation with ORIF (Group C):

ORIF is performed through the anteromedial approach to the distal tibia. Careful dealing with soft tissue during every step for the anatomical reduction and fixation technique. Also, attention must be paid to maintaining the distal tibial length and normal sagittal, coronal, and axial alignment. The approach and method of fixation depend on the fracture pattern. The six fracture fragments: anterolateral, posterolateral, anterior, posterior, medial, and central die-punch fragments must be reduced anatomically starting with temporary smooth k wires, and then the medial and anterolateral tibial columns are fixed with anatomical locked distal tibial plate. A limited lateral approach may be added to gain access for lag screws fixation of the displaced lateral bone fragment.

Follow-up Protocol:

The adequate fracture reduction during the first postoperative period was assessed according to the Conroy et al. scale that was applied on the plain X-ray of all 40 patients. Based on their standards, an excellent. reduction of <2 mm in joint incongruity, and <5° of metaphyseal-diaphyseal angulation in the coronal direction. A good reduction was defined as 2.5–5 mm of joint incongruity and 5°- 10o of metaphyseal-diaphyseal angulation in the coronal direction. For joint incongruity, greater than 5 mm and coronal plane metaphyseal-diaphyseal angulation greater than 10°, a poor reduction evaluation was assigned. Malunion was defined as fractured healing exhibiting at least one of the following: internal rotation of 10°, external rotation of more than 15°, or shortening of at least 2 cm. Nonunion was defined if no sign of healing six months later with Radiographs showing sclerotic change. (20)
The patients were followed at regular intervals postoperatively, including outpatient visits at 1, 3, 6, 12, and 24 months. Follow-up assessments included radiographic evolution; ankle plain x-ray and CT scan to assess stability, quality of reduction, and union of the fractures. Clinical evaluation: infection, pain, ankle range of motion.

Outcome Measures:

Primary outcome measures included postoperative complications, time to fracture union, and functional outcomes assessed using the Association for the Study and Application of Methods of Ilizarov (ASAMI) scoring system (21) and the American Orthopaedic Foot and Ankle Society (AOFAS). (22) Secondary outcomes encompassed patient satisfaction, return to daily activities, and the need for additional interventions.

Statistical Analysis: A computer running a social science statistical program (SPSS 25) was used to clean, code, calculate, and import the collected data. Based on the type of data gathered for every metric, information was presented and appropriately analyzed. Scale measurement and population value were compared using a single sample t-test. The scale's measurements over time were compared for the VAS score using a paired sample t-test. To measure how strongly continuous variables are related to one another, Pearson correlation was used.

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RESULTS

The mean age of the participants was 35.78 ±12.01 SD (ranged from 20 to 70) years. There were 33 males (82.5%) and 7 girls (17.5%). Sixteen (40%) patients were smokers. Four patients (10%) were diagnosed with diabetes mellitus: one (8.33%) group A , one (12.5%) group B, two (10%) group C, two (5%) had hypertension one (12.5%) group B, one (5%) Group C, one (5%) Group C was diagnosed with psoriasis, and one (5%) Group C was using psychotic medicines. Age, sex, comorbidities, smoking, mechanisms of injury, AO/OTA, and Rüedi, Allgöwer (RA) fracture classifications systems, and operative time were recorded in Table 1, which were insignificantly different between the studied groups. Gustilo- Anderson classification for open fractures (OG) significantly differed between groups A and B (P value 0.048), with no significant difference between groups A, C, and B, C (figure 2).

No recorded cases of pre or post-operative neurovascular injuries or compartmental syndrome (leg or foot). The time interval between trauma and operation was significantly longer in group C than in groups A and B (P value 0.013 and 0.050, respectively). In group A, the DF was primary So, it was removed after a mean time of 17 (ranging from 11 to 21) days, and the definitive fixation was performed with ORIF (Table 1).

		Group A (n=12)	Group B (n=8)	Group C (n=20)	P value
Age (years)	Mean ± SD	35.92 ± 15.54	35.88 ± 9.73	35.65 ± 11.01	P = 0.998
	Range	20 – 70	27 - 54	21 – 61	
Gender	Male	10 (83.33%)	8 (100%)	15 (75%)	P = 0.289
	Female	2 (16.67%)	0 (0%)	5 (25%)	
Smoking	Smoker	6 (50%)	4 (50%)	6 (30%)	P = 0.166
	Heavy smoker	5 (41.67%)	2 (25%)	4 (20%)	
	Non-smoker	1 (8.33%)	2 (25%)	10 (50%)	
Comorbidities	DM	1 (8.33%)	1 (12.5%)	2 (10%)	P = 0.868
	HTN	0 (0%)	1 (12.5%)	1 (5%)	
	Psoriasis	0 (0%)	0 (0%)	1 (5%)	
	On psychotic drugs	0 (0%)	0 (0%)	1 (5%)	
Mechanism of injury	FFH	5 (41.67%)	6 (75%)	10 (50%)	P = 0.628
	MCA	6 (50%)	2 (25%)	8 (40%)	
	Twisting trauma	1 (8.33%)	0 (0%)	2 (10%)	
Rüedi and Allgöwer Classification System	I	3 (25%)	2 (25%)	5(25%)	P = 0.093
	II	6 (50%)	2 (25%)	10 (50%)	
	III	3 (25%)	4 (50%)	5 (25%)	
Open fractures classification Gustilo-anderson	OG I	5 (0%)	1 (37.5%)	0 (0%)	P = 0.016* P1 =0.048* P2 =0.053 P3 =0.263
	OG II	3 (8.33%)	2(12.5%)	0 (0%)	
	OG III	0 (0%)	3(0%)	0 (0%)	
Closed injuries	Closed	4(50%)	2 (50%)	20 (100%)	

The time between trauma and operation (days)	Median	1	2	5.5	P = 0.021* P1 =0.842 P2 =0.013* P3 =0.050*
	IQR	1 - 3.25	1 - 3.75	3.75 – 9	
Operative duration (hours)	Mean ± SD	2.23 ± 1.03	2.94 ± 0.9	2.21 ± 0.52	P = 0.080
	Range	1 – 4	1.5 - 4	1.5 – 3	

Table 1: demographic data, mechanism of injuries fracture classifications, time interval, and operative durations. (DM: diabetes mellitus, HTN: hypertension. FFH: fall from height, IQR: interquartile range, *: significant as P value ≤ 0.05, P1: P value between group A and group B, P2: P value between group A and group C, P3: P value between group B and group C).

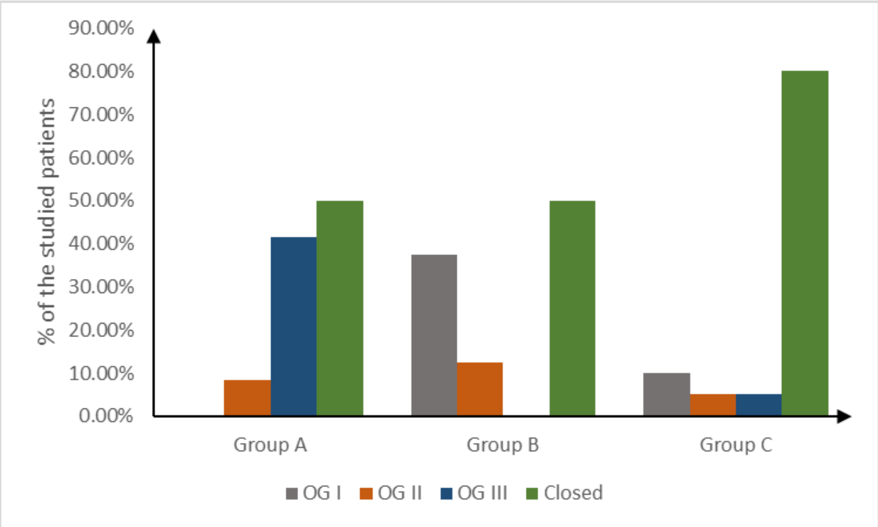

Figure 2: open fractures (Gustilo-Anderson classification) compared to closed fractures between the 3 groups.

The ORIF was performed in groups A and C through the anteromedial approach in 100% of cases, and the limited lateral approach was added in 10 (31.25%) patients. According to the Conroy et al. scale, the adequacy of the anatomical reduction was; Excellent in 19 (47.5%) cases, good in 17 (42.5%) cases, and poor in 4 (10%) cases. The adequacy of anatomical reduction was significantly higher in group C than in groups A and B (P value <0.001 and 0.001, respectively), with no significant difference between groups A and B. The adequacy of the anatomical reduction was significantly lower in RA III fractures than in RA I and II (P value <0.001) (Table 2).

Group	Adequacy of fracture reduction			p-value
	excellent	Good	poor	
Group A	7 (36.8%)	4 (23.5%)	0 (0%)	P=<0.001* P1 =0.761 P2 <0.001* P3 =0.001*
Group B	2 (10.5%)	5 (29.4%)	2 (50%)	
Group C	10 (52.7%)	8 (47%)	2 (50%)	
total	19 (100%)	17 (100%)	4 (100%)	

Table 2: the adequacy of the anatomical reduction. (*: significant as P value ≤ 0.05, P1: P value between group A and group B, P2: P value between group A and group C, P3: P value between group B and group C).

The duration of hospitalization (weeks) was insignificantly different between the studied groups. Union time (weeks) was insignificantly different between the studied groups. The mean follow-up time is 12 (10-17) months. Complications (delayed union, nonunion, ankle stiffness, shortening, infection, Sudeck's atrophy, and skin complications) differed insignificantly between the studied groups. In group C of our study, 1 (5%) case of late postoperative infection that was treated successfully by plate removal, 2 (10%) cases of skin breakdown treated with the surgical vac system followed by partial thickness skin graft, and the other cases treated by a local rotational skin flap. Ankle stiffness was recorded in 8 (20%) cases that improved with physiotherapy within 6 months of starting weight bearing, with no cases of postoperative loss of fracture stability, non-union, neurovascular injuries or compartmental syndrome. The functional ASAMI scoring system was insignificantly different between the studied groups. AOFAS was significantly excellent in group C than in group A (P value 0.028) with no significant difference between groups A, B, and B, C. Ankle motion was insignificantly different between the studied groups (Table 3). Figures 3 and 4 showed 2 illustrative cases of the study.

		Group A (n = 12)	**Group B (n = 8)**	**Group C (n = 20)**	**P value**
Duration of hospitalization	2-3 weeks	7 (58.33%)	6 (75%)	14 (70%)	0.613
	3-4 weeks	4 (33.33%)	2 (25%)	6 (30%)	
	> 4 weeks	1 (8.33%)	0 (0%)	0 (0%)	
Union time (weeks)	12-14 weeks	3 (25%)	2 (25%)	10 (50%)	0.185
	15-18 weeks	4 (33.33%)	3 (37.5%)	8 (40%)	
	19-24 weeks	3 (25%)	3 (37.5%)	2 (10%)	
	> 25 weeks	2 (16.67%)	0 (0%)	0 (0%)	
complications	Delayed union	2 (16.67%)	0 (0%)	1 (5%)	0.451
	Nonunion	1 (8.33%)	0 (0%)	0 (0%)	
	Stiffness of ankle	1 (8.33%)	3 (37.5%)	5 (25%)	
	Shortening	0 (0%)	1 (12.5%)	0 (0%)	
	Infection	2 (16.67%)	1 (12.5%)	1 (5%)	
	Sudeck's atrophy	3 (25%)	1 (12.5%)	5 (25%)	
	Skin complications	0 (0%)	0 (0%)	2 (10%)	
ASAMI score	Poor	1 (8.33%)	0 (0%)	0 (0%)	0.456
	Fair	4 (33.33%)	2 (25%)	6 (30%)	
	Good	4 (33.33%)	5 (62.5%)	6 (30%)	
	Excellent	3 (25%)	1 (12.5%)	8 (40%)	
AOFAS	Poor	2 (16.67%)	0 (0%)	0 (0%)	P = 0.036
	Fair	4 (33.33%)	1 (12.5%)	1 (5%)	
	Good	3 (25%)	6 (75%)	10 (50%)	P1 =0.157
	Excellent	3 (25%)	1 (12.5%)	9 (45%)	P2 =0.028* P3 =0.251
Ankle dorsiflexion range	1/2	6 (50%)	4 (50%)	5 (25%)	0.25
	3/4	5 (41.67%)	3 (37.5%)	7 (35%)	
	Full	1 (8.33%)	1 (12.5%)	8 (40%)	

Table 3: data of the hospital stay, fractures union rate, complication, and the functional outcome score. (*: significant as P value ≤ 0.05, P1: P value between group A and group B, P2: P value between group A and group C, P3: P value between group B and group C).

Figure 3: Male patient, 24 years old, falling from height (A) X-ray showed pilon fracture type B. (B) CT scan cuts show the degree of comminution and articular surface fracture lines. (C) four months post-operative x-ray showed healing of the fracture and fixation with the medial buttress plate and augmented by an additional anteroposterior lag screw for the anterolateral fragment. (D) X-ray showed removal of the implants and complete solid union, after a 13-month follow-up, there is mild ankle arthritis. (E) Clinical photos show accepted ankle range of motion 15-month follow-up.

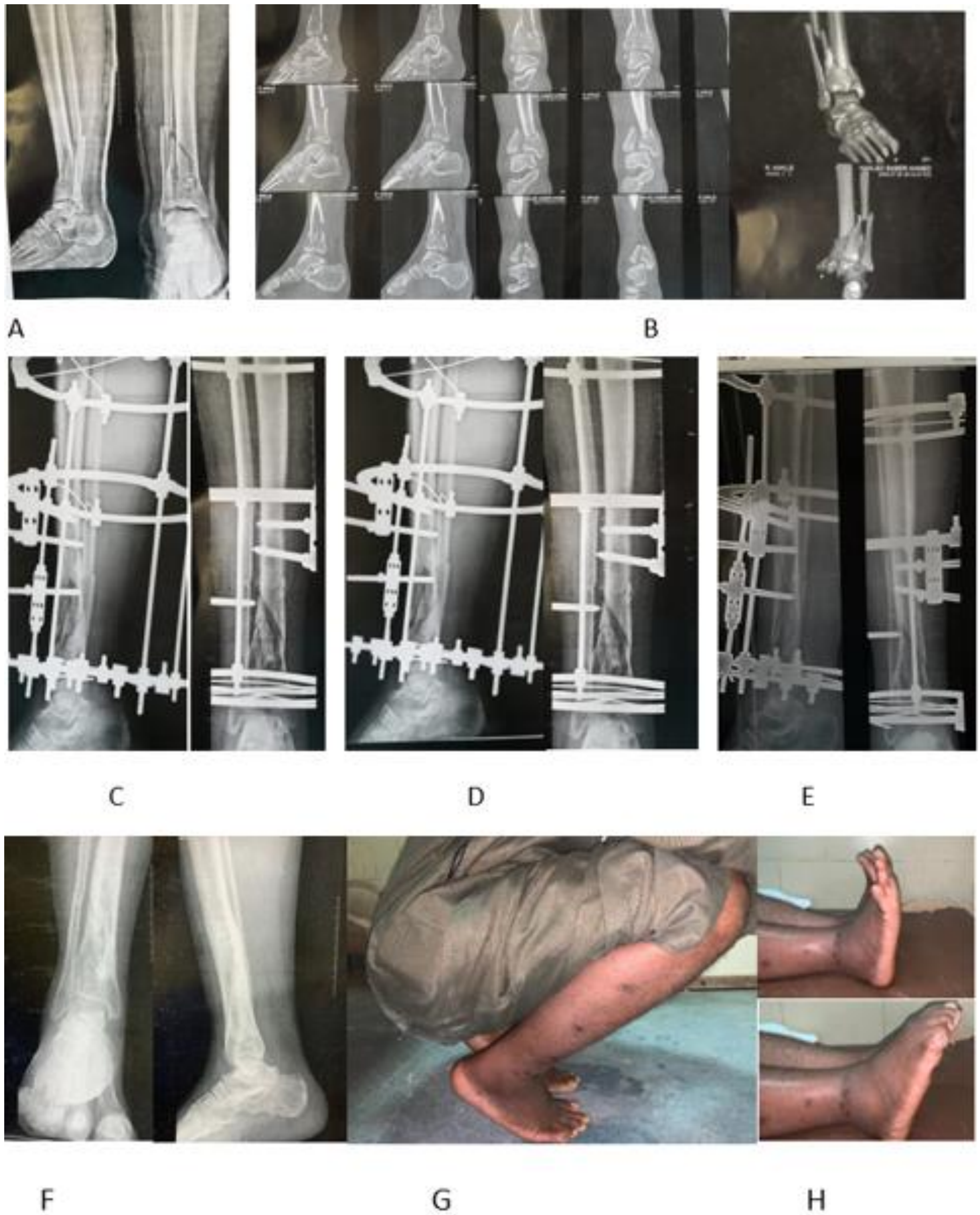

Figure 4: Male patient, 30 years old, motor car accident, (A) X-ray showed pilon Fracture with ipsilateral Fracture ankle type C. (B) CT scan showed the articular surface and metaphyseal comminution. (C) The patient was operated on with definitive IF. (D) three months follow-up. (E) At 6 Months Follow-up, X-ray shows Ilizarov removal after the complete bone union. (F) Follow-up after 12 months, normal ankle ROM.

DISCUSSION

Many important factors affect the outcomes of pilon fracture management: (a) the severity of the soft-tissue damage, (b) the fracture classification, (c) the Timing, approach, and technique of the surgical interference, (d) the attention for the preservation of the anatomical reduction of the articular surface and the mechanical alignment (e) proper postoperative care (1-4,11, 23 - 27).

Associated soft tissue damage with pilon fracture almost have a hidden injured zone that appears days later after the time of trauma in the form of severe oedema, blisters, and skin breakdown or necrosis, so if the ORIF is planned, these injured tissue needs a time interval to allow healing and skin re-epithelialization, where the appearance of skin wrinkle signs is the surgery time for healing to avoid postoperative catastrophic complications (24). So, in our study, we recorded a longer median time interval with group C than group A and group B with significant differences (p-value = 0.021). the median time interval was 1 (IQR, 1 – 3.25), 2 (IQR, 1 – 3.75), and 5.5 (IQR, 3.75 - 9) days for groups A, B, and C respectively. Duckworth et al. recorded that the median time interval to definitive operation was 2 (IQR, 1 to 5) days, in their retrospective study, where 73 (71.6%) fractures underwent primary ORIF, 20 (19.6%) underwent external fixation then delayed ORIF, 6 (5.9%) underwent combined primary ORIF protected with external fixator at the same time, and 3 (2.9%) underwent primary arthrodesis. (25)

In this current study, we performed the primary ORIF in the 20 patients of group C, where the AOFAS was excellent in 9 (45%) patients, good in 10 (50%), and fair in 1 (5%). As regards complications within this group, 1 (5%) case suffered from postoperative infection. Skin breakdown was recorded in 2 (10%) cases. In Group A and Group B, no recorded cases of skin complications.

Chen et al. reported using ORIF to treat 128 cases with pilon fractures, 90 closed and 38 open fractures (OG II or III). Sixteen of the 38 were open and treated in temporary external fixation followed by ORIF. The deep infection between the open fractures was 5.5%, while osteomyelitis was 3.1%. (27)

Duckworth et al. documented 36 complications in 28 patients (27.5%), the complication rate was 35.2%. Eighteen (17.6%) patients suffered from infections, nonunion in 9 (8.8%) fractures, loss of reduction in 6 (5.9%), deep peroneal nerve neuropraxia in 1 (1%), acute compartment syndrome in 1 (1%), and complex regional pain syndrome in 1 (1%). The mean AOFAS at a mean of 6 (0.3 to 13) years post-injury was 76.2 (0 to 100). (25)

Wei et al. reported a 20% (14 cases) complication rate in their study; 11 (15.7%) cases with Skin breakdown, nonunion in one (1.5%) case, and nerve palsy in 2 (2.8%) cases. AOFAS score was more than 83.0. (24) Esposito et al. reported that independent risk factors for infection are the need for soft tissue coverage and smoking. (26) Duckworth et al. concluded that the postoperative infection rate (17.6%) in their study was related to comorbidities (p-value = 0.008), open fractures (p-value = 0.008), and staged procedures (p-value = 0.023). (25) The infection rates of other studies by Sirkin et al (28), Ovadia and Beals (29), and Teeny and Wiss (30), were 5.3%, 7%, and 37% respectively.

The AO recommendation is to use two-stage surgery using temporary external fixation spanning the whole fracture area and then shifting to definitive ORIF to achieve anatomical articular surface reduction and normal distal tibial alignment (31, 32).

Recently, it has been stated that the Ilizarov ring fixator technique is a definitive effective treatment method for severe pilon fractures with a low rate of serious complications (30-32). Mostly severe complex fractures (RA II and III) or open fractures (OG III) need the circular IF. (33) In our study, we treated 8 cases of group B with pilon fractures with primary IF, 7 (87.5%) cases of them were type C had extended ring in calcaneus beyond the ankle then removed after one and half months. IF reported short hospital time (less than 4 weeks), less time interval (2.94 ± 0.9 days), 1 case pin tract infection. The union rate was 100% within 24 weeks, with 1 case with shortening (1.5cm) and 3 cases of stiff ankle improved with physiotherapy. Regarding AOFAS, 1 case was excellent, 6 were good, and 1 was fair, and overall satisfactory ankle ROM.

Pugh et al compared external fixators spanning, ORIF, and hybrid fixator procedures and reported that the ORIF was associated with soft tissue complications, and the malunion was associated with the external fixation techniques. (34) Mauffrey et al. stated that pin tract infection is frequently associated with external fixation (IF or DFF). (33) Also, Vidyadhara et al. reported the results of treating 21 cases with pilon fractures. They reported that the fracture union was completed within 27 weeks, 7 patients suffered from pin tract infection, and no cases of pin tract infection. (35) Retrospectively, McDonald et al. analyzed the result of using IF to treat 13 cases of pilon fractures. They reported 11 fractures united by the 16th week, 1 delayed union needed a bone graft, 1 nonunion was treated with ankle arthrodesis, and no deep infection. (36) Esposito et al. documented whether IF or two-stage surgery is the reliable and safe method to avoid skin complications, the probability of which is high with ORIF (one-step surgery). (26)

According to the Conroy et al. scale, the overall adequacy of the immediate postoperative anatomical reduction was; Excellent was19 (47.5%), good was 17 (42.5%), and poor at 4 (10%), while it was excellent at 36.8% of group A, 10.5% of group B, and 52% of group C. a good reduction was achieved in 23.5% of group A, 29.4% of group B, and 47% of group C, while poor in 50% of group B, and 50% of group C. The adequacy of anatomical reduction was significantly higher in group C than in groups A and B (P value <0.001). In the study of Chen et al, which included 128 that managed by one stage ORIF, however, the adequacy of the immediate anatomical reduction was excellent in 37.5%, good in 49.5%, poor in 13% of cases, and significantly lower in RA III fracture types than others (p > 0.05). (27) Biçici et al. reported that the adequacy of the immediate postoperative anatomical reduction was; Excellent 51 (63%), good 21 (26%), and poor 9 (11%). while it was excellent in 25 (49%) of group A, 8 (15.7%) of group B, and 18 (35.3%) of group C. a good reduction was achieved in 6 (28.7%) of group A, 12 (57%) of group B, and 3 (14.3%) of group C, while poor in 2 (22%) of group A, and 5 (56%) of group B, 2 (22%) of group c. The adequacy of anatomical reduction was significantly higher in group C than in groups A and B (P-value <0.001). (37)

In our study, the functional ASAMI scoring system was insignificantly different between the studied groups. AOFAS was significantly excellent in group C than in group A (P value 0.028) with no significant difference between groups A, B, and B, C. Biçici et al. treated 89 pilon fractures by different modalities; in group A by primary ORIF and group B by primary IF and temporary external fixation followed by ORIF in group C. Regarding AOFAS, no significant difference was recorded between the 3 modalities (P = 0,880). Skin complication was recorded in 6 (15.7%) cases of group A while 0% was in group B. (37) In terms of skin complications, we discovered that Ilizarov and two-stage surgical treatment is a more dependable approach, and our findings are consistent with previous research. (25-37)

Limitation of the study;

The study's generalizability may be limited due to the relatively small sample size of 40 patients, raising concerns about statistical power and the ability to detect meaningful differences. The unequal distribution of patients across the three groups (Group A: 12, Group B: 8, Group C: 20) may introduce a potential bias in the interpretation of results. Also, our study is limited by the absence of long-term complications such as gait disturbance, tibiotalar joint deformities, and ankle arthrosis. The points of strength; The inclusion of three distinct groups allows for a comparative analysis, providing insights into potential variations in outcomes among different fixation modalities. The prospective nature of the study, with data collected from the initiation of interventions, strengthens the quality of evidence compared to retrospective designs.

CONCLUSION

Primary IF is the best treatment for all open and closed type RA III pilon fractures. It is more successful than primary ORIF surgery due to the potential for wound complications. primary ORIF is the ideal option for closed pilon fracture RA I and II with mild oedema. Temporary DFF followed by ORIF is reliable for open fracture RA I and III.

REFERENCES

1. Teeny SM, Wiss DA. Open reduction and internal fixation of tibial plafond fractures: variables contributing to poor results and complications. Clin Orthop Relat Res. 1993; 292:108–117.
2. Rüedi TP, Allgöwer M. Fractures of the lower end of the tibia into the ankle-joint. Injury. 1969;1:92–99. doi: 10.1016/S0020-1383(69)80066-5.
3. Lavini, F., Dall'Oca, C., Mezzari, S., Maluta, T., Luminari, E., Perusi, F & Magnan, B. Temporary bridging external fixation in distal tibial fracture. Injury 2014, 45, S58-S63.
4. Tomás-Hernández, J. High-energy pilon fractures management: state of the art. EFORT open reviews, 2016, 1(10), 354-361.
5. T. David Luo, MD, J. Matthew Eady, PharmD, Arun Aneja, MD, PhD, and Anna N. Miller, MD Classifications in Brief: Rüedi-Allgöwer Classification of Tibial Plafond Fractures. Clin Orthop Relat Res. 2017 Jul; 475(7): 1923–1928. . doi: 10.1007/s11999-016-5219-z
6. Jacob N, Amin A, Giotakis N, Narayan B, Nayagam S, Trompeter AJ. Management of high-energy tibial pilon fractures. Strat Trauma Limb Recon 2015; 10: 137-47.
7. Topliss CJ, Jackson M, Atkins RM. Anatomy of pilon fractures of the distal tibia. J Bone Joint Surg Br 2005; 87: 692-7.
8. David A. Ibrahim, MD, Alan Swenson, MD, Adam Sassoon, MD, and Navin D. Fernando, MD :Classifications In Brief: The Tscherne Classification of Soft Tissue Injury. Clin Orthop Relat Res. 2017 Feb; 475(2): 560-564.
9. Paul H. Kim, MD and Seth S. Leopold: Gustilo-Anderson Classification. Clin Orthop Relat Res. 2012 Nov; 470(11): 3270–3274. doi: 10.1007/s11999-012-2376-6
10. Pamudji Utomo1, Mujaddid Idulhaq, Muhammad Abdulhamid: A Current Concepts Update in Pilon Fracture Management . Open Access Maced J Med Sci. 2022 Jun 16; 10(F):475-486.
11. T. David Luo, MD, J. Matthew Eady, PharmD, Arun Aneja, MD, PhD, and Anna N. Miller, MD Classifications in Brief: Rüedi-Allgöwer Classification of Tibial Plafond Fractures. Clin Orthop Relat Res. 2017 Jul; 475(7): 1923–1928. Published online 2017 Jan 4. doi: 10.1007/s11999-016-5219-z
12. Vito N Galante, Giovanni Vicenti, Gianfranco Corina, Claudio Mori ,, Antonella Abate, Girolamo Picca, Vito Conserva, Domenico Speciale, Lorenzo Scialpi, Nicola Tartaglia,Vincenzo Caiaffa, Biagio Moretti: Hybrid external fixation in the treatment of tibial pilon fractures: A retrospective analysis of 162 fractures. Injury. 2016 Oct: 47 Suppl 4: S131-S137. doi: 10.1016/j.injury.2016.07.045.
13. Elias S Vasiliadis, Theodoros B Grivas, Spyridon A Psarakis, Evangelos Papavasileiou, Angelos Kaspiris and Georgios Triantafyllopoulos: Advantages of the Ilizarov external fixation in the management of intra-articular fractures of the distal tibia. Journal of Orthopaedic Surgery and Research 2009, 4:35 doi:10.1186/1749-799X-4-35
14. Thordarson DB: Complications after treatment of tibial pilon fractures. Prevention and Management strategies. J Am Acad Orthop Surg 2000, 8:253-265
15. Müller ME, Allgöwer M, Schneider R, Willenegger H: Manual of Internal Fixation. Technique Recommended by the AO Group. 2nd edition. New York, Springer; 1979.
16. Griend R Van der, Michelson JD, Bone LB: Fractures of the Ankle and the Distal Part of the Tibia. In Instructional Course Lectures Volume 46. The American Academy of Orthopaedic Surgeons, Rosemont, Illinois; 1997.
17. Williams TM, Nepola JV, DeCoster TA, Hurwitz SR, Dirschl DR, Marsh JL: Factors Affecting Outcome in Tibial Plafond Fractures. Clin Orthop 2004, 1(423):93-98.

18. Blauth M, Bastian L, Krettek C, Knop C, Evans S: Surgical options for the treatment of severe tibial pilon fractures: a study of three techniques. J Orthop Trauma 2001, 15:153-160
19. Patterson MJ, Cole DJ: Two-staged delayed open reduction and internal fixation of severe pilon fractures. J Orthop Trauma 1999, 2:85-91.
20. Conroy J, Agarwal M, Giannoudis PV, Matthews SJ. Early internal fixation and soft tissue cover of severe open tibial pilon fractures. Int Orthop. 2003;27(6):343-7. doi: 10.1007/s00264-003-0486-1. Epub 2003 Jul 8. PMID: 12851785; PMCID: PMC3461889.
21. Gianluca Testa , Andrea Vescio , Domenico Costantino Aloj , Danilo Costa , Giacomo Papotto , Luca Gurrieri , Giuseppe Sessa 1 and Vito Pavone :Treatment of Infected Tibial Non-Unions with Ilizarov Technique: A Case Series. J. Clin. Med. 2020, 9, 1352; doi:10.3390/jcm9051352
22. Baumhauer JF, Nawoczenski DA, DiGiovanni BF, Wilding GE. Reliability and validity of the American Orthopaedic Foot and Ankle Society Clinical Rating Scale: a pilot study for the hallux and lesser toes. Foot Ankle Int. 2006 Dec;27(12):1014-9. doi: 10.1177/107110070602701202. PMID: 17207425.
23. Saad BN, Yingling JM, Liporace FA, Yoon RS. Pilon fractures: challenges and solutions. Orthopedic Research and Reviews 2019; 11: 149-157. doi: 10.2147/ORR.S170956
24. Shi-jun Wei, Fang Han, Sheng-hui Lan, Xian-hua: Surgical treatment of pilon fracture based on ankle position at the time of injury/initial direction of fracture displacement: A prospective cohort study. International Journal of Surgery 12 (2014) 418-425.
25. Duckworth AD, Jefferies JG, Clement ND, White TO. Type C tibial pilon fractures: short- and long-term outcome following operative intervention. Bone Joint J. 2016 Aug;98-B(8):1106-11. doi: 10.1302/0301-620X.98B8.36400.
26. John G Esposito, Quirine M J van der Vliet , Marilyn Heng , Jeffrey Potter , Patrick K Cronin , Mitchel B Harris , Michael J Weaver : Does Surgical Approach Influence the Risk of Postoperative Infection After Surgical Treatment of Tibial Pilon Fractures?. J Orthop Trauma. 2020 Mar;34(3):126-130. doi: 10.1097/BOT.0000000000001655.
27. Shih-Hao Chen · Po-Hui Wu · Yih-Shiunn Lee: Long-term results of pilon fractures. Arch Orthop Trauma Surg (2007) 127:55–60 DOI 10.1007/s00402-006-0225-3.
28. Sirkin M, Sanders R, DiPasquale T et al (2004) A staged protocol for soft tissue management in the treatment of complex pilon fractures. J Orthop Trauma 18(8 suppl):S32– S38.
29. Ovadia DN, Beals RK (1986) Fractures of the tibial plafond. J Bone Joint Surg Am 68:543–551.
30. Teeny SM, Wiss DA (1993) Open reduction and internal Wxation of tibial plafond fractures. Clin Orthop 292:108–117.
31. Dunbar RP, Barej DP, Kubiak EN, Nork SE, Henley MB. Early limited internal fixation of diaphyseal extensions in select pilon fractures: upgrading AO/OTA type C fractures to AO/OTA type B. J Orthop Trauma 2008 ; 22 : 426-429.
32. Kline AJ, Gruen GS, Pape HC et al. Early complications following the operative treatment of pilon fractures with and without diabetes. Foot Ankle Int 2009 ; 30 : 1042- 1047.
33. Cyril Mauffrey, Gabriel Vasario, Bruno Battiston, Chalie Lewis, James Beazley, David Seligson:Tibial pilon fractures :A review of incidence, diagnosis, treatment, and complications. Acta Orthop. Belg., 2011, 77, 432-440
34. Pugh K, Wolinsky P, McAndrew M, Johnson K. tibial pilons Fractures: a comparison of treatment methods for. J Trauma-Injury Infect Crit Care 1999; 47: 937.
35. Vidyadhara S, Rao SK. Ilizarov treatment of complex tibial pilon fractures. Int Orthop 2006; 35: 113-7.

36. McDonald MG, Burgess RC, Bolano LE, Nicholls PJ. Ilizarov treatment of pilon fractures. Clin Orthop Relat Res 1996; 325: 232e8.
37. Biçici V, Bingöl İ. Do different surgical techniques in tibia pilon fractures change the results of the midterm? Turk J Med Sci. 2020 Oct 22;50(6):1559-1565. doi: 10.3906/sag-2006-212.